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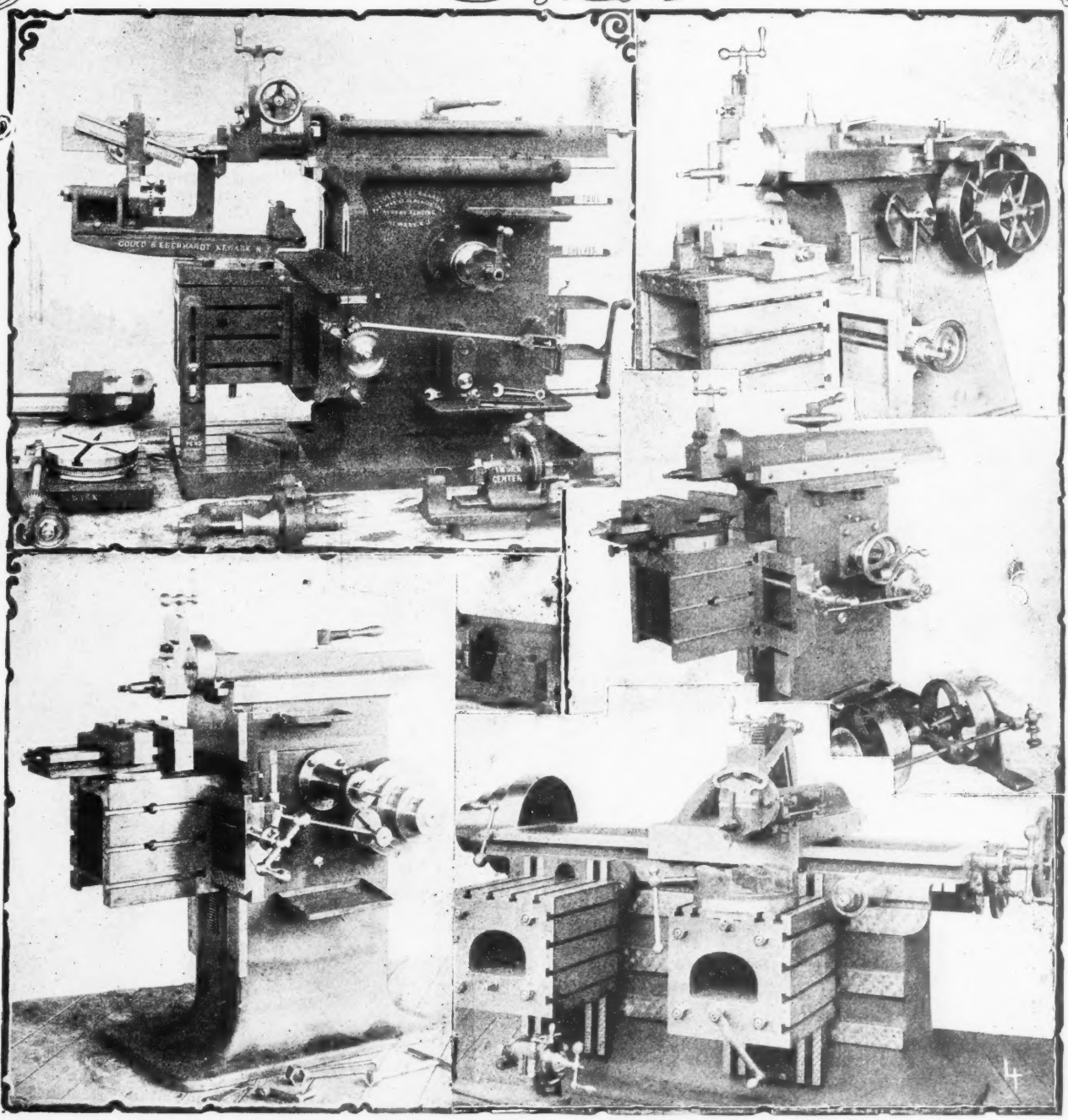

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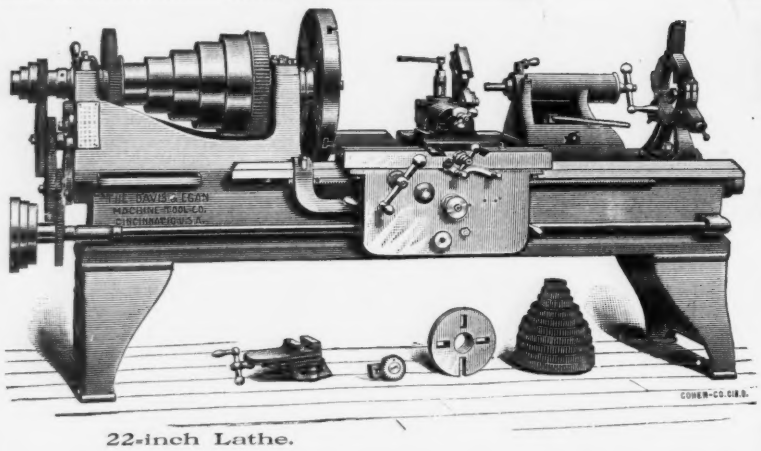

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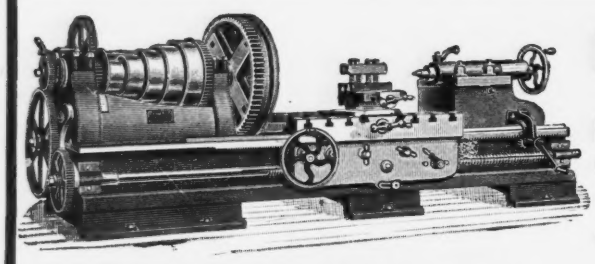

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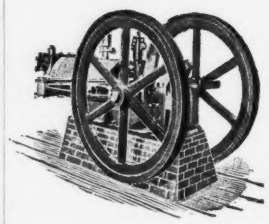

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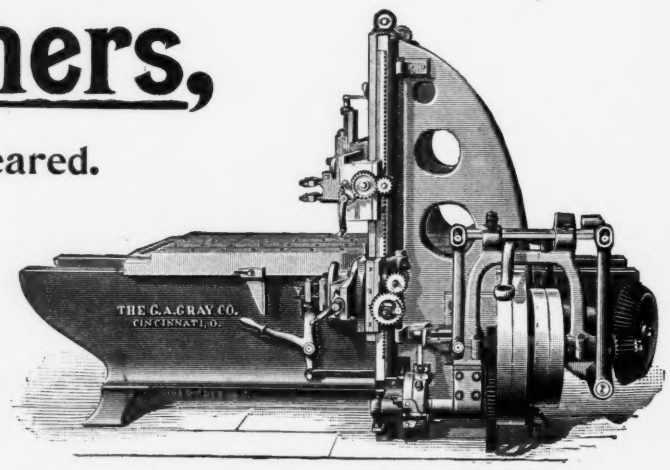

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MACHINERY.

VOL. 2. May, 1896. No. 9.

MAGNESIUM AS A CONSTRUCTIVE MATERIAL.

R. H. THURSTON.

THE wonderful development, during recent years, of the production and application of aluminium, and the hardly less remarkable extent to which it has been brought into use in new fields of construction and production, have fully justified the anticipation, once hardly amounting to more than the hope, that the now rare metals and their alloys may, at some future time, come to be hardly less useful, possibly in some directions, even more so, than the familiar metals of engineering construction. The chemist is familiar with a long list of as yet unused metals, rare and costly hitherto, the introduction of which into the market at commercially satisfactory prices might probably be followed by innumerable applications to new and useful purposes in the arts. These are, usually, the alkaline metals and those of the alkaline earths; but the readiness with which these are oxidized on exposure to the air, and usually, their extreme softness, make it improbable that they will find very general use, except in alloys, however cheap their production may come to be.

R. H. Thurston

Metals like palladium, iridium, titanium, are among those still to be studied and rendered useful. Manganese, chromium, aluminium, nickel, are rapidly becoming more available as the demand, which is continually increasing, brings as steadily a larger and larger market for the producer; and where the compounds or alloys produced by direct reduction are especially needed, costs of the pure metal becomes comparatively unimportant. No metal can find use in general engineering which costs in the market, in large quantities, more than about ten cents per pound at present; while ten times this figure may not prevent extensive use in ornamental work and the decorative art, and the price of gold represents the figure of maximum cost for pure ornament in the jeweler's constructions. With the naturally rare metals, as gold and platinum, extensive demand usually raises prices; but, in the case of the extensively distributed metals, where costs are those of reduction simply, large demand commonly induces such applications of ingenuity and special knowledge, such rapid introduction of new inventions and processes, as rapidly to bring down prices to a commercially satisfactory standard. This fact is now well illustrated in the case of aluminium; which sold at $16.00 a pound ten years ago and less, and is now obtainable at fifty cents.

The special requirement of the engineer is a material for his constructive purposes which shall be at once strong, elastic, resilient, light, non-oxidizable, cheap in first cost and in costs of modification of form. He desires it to be malleable and fusible, to make good forgings and sound castings. Steel, at present, is the best illustration of the engineer's ideal material of construction. In this metal he finds the best combination of strength with comparative, if not absolute, lightness, adaptability to his every purpose and low cost both of production and of working. For structures in which only static stresses are to be met, it is admirable; for machinery, especially for apparatus of transportation, it would be better if lighter.

It has long since come to be recognized that we are to seek, for all the arts of construction, new materials, especially for use in machinery of transportation, which shall most completely and satisfactorily combine strength with lightness. If dense they must be very strong; if light, they must not be more than proportionally weak. They may be, in many cases, perfectly satisfactory in one form and entirely worthless in another; as silk, in tension, the strongest substances, density considered, is useless in comparison and for transverse loading; cast iron, often most valuable for compressive loading, is undesirable for tension members. The material being found and its value recognized, we may usually, as is so strikingly illustrated in the case of aluminium, trust to the ingenuity of our chemists, our physicists, our engineers, to make it commercially available. In this search for new materials, we may find ourselves on the verge of a possible discovery of a new material of engineering in the hitherto unknown investigated list of rare metals, as in the case of magnesium, to be presently brought forward by the writer as such a possible illustration of a happy accident. We may find it practicable to secure improvement of known metals by alloying with new, *e. g.*, it has now been well established that aluminium may be given a doubled tenacity by small doses of other metals. We may also find new ways of utilizing the well-known metals, and special familiar constructive forms, by new methods of introduction into our constructions, as by finding ways of substituting fine steel wire or ribbon, with its quadrupled tenacity, for the same metal in bars and rods as commonly used.

Magnesium, although still a rare metal and somewhat costly, has always seemed to the writer a possible future rival of the more common metals of construction where a combination in maximum degree of lightness and strength is essential. His work on that material began nearly thirty years ago, at about the close of the civil war, when he used it in a long series of experiments looking toward the production of an economical and otherwise satisfactory signal-light for army and navy use.* The metal is not strong, but is very light. Weighing only about two thirds

* On a New Marine Signal Light; Journal Franklin Institute, 1867. The first patents in the U. S. on magnesium lamps were those granted the writer, May, 1866, and subsequently.

as much as aluminium, and between one fourth and one fifth as much as iron or steel, it seems more likely, as is the case with aluminium, to prove serviceable in alloys than pure.

The pure metal resembles nickel, aluminium and other white metals in color, is soft and weak, oxidizes more readily than either of the preceding, and, in the form of ribbon or of powder, burns readily, steadily and brilliantly. Its light is very rich in the actinic rays and is so bright as to be visible, when used as a signal, at the distance of thirty miles or more at sea. Chlorine and hydrochloric acid attack it rapidly, sulphuric acid but slowly. It combines readily with many of the other metals, and forms alloys which are usually too hard and brittle to be useful in the arts. It is sufficiently malleable and rolls into ribbons and sheets. It has not that combination of strength and ductility requisite for successful wire-drawing. The following are its physical constants:

PROPERTIES OF MAGNESIUM.

Specific gravity	1.743 (109 lbs. per cu. ft.)
Specific heat	0.2499.
Atomic weight	2394.
Melting point	433° C., 811° F.
Boiling point	800° C., 1472° F.
Electric conductivity	41 2.
Tenacity, per sq in	22 000 to 32 000 lbs.
Compression resistance	37 000 lbs.
Bending modulus	23 750 lbs.
Length sustainable	28 000 to 42 000 ft.

Its flame has a temperature of about 1340° C. (2444° F.), but the light is similar to that of an ordinary flame at three times this temperature. Its radiant light energy is 13 5 per cent.—a higher figure than that of any other known flame, constituting three fourths its total energy of combustion and four times that of illuminating gas. Its total light-giving efficiency is ten per cent, as against one fourth of one per cent. for gas, and taking into account the greater luminosity of its light rays, it has fifty or sixty times the value of gas. Its spectrum is nearer that of sunlight than that of any other as yet discovered artificial illuminant.*

Magnesium is usually obtained by reduction from flour spar with sodium, but it may also be reduced by the electric arc, like aluminium, and it is very possible that, once its valuable properties and possible applications have attracted attention, it may be produced in quantity very cheaply.

It is quite easily distilled and may be thus purified successfully. The spectrum indicates a close relation between magnesium and aluminium; both giving bands in the yellow and green, of which those of the former are noticeably duller than those of the latter.

The successful introduction of aluminium into the arts, notwithstanding some disappointment on the part of the engineer in his hope of securing exceptional combinations of strength and lightness for use in machinery of transportation especially, has seemed to the writer reason for anticipating a possible development of applications, and a market for other metals of somewhat similar characteristics, and of possibly even greater promise of usefulness in themselves or in their alloys. He, therefore, procured a quantity of the as yet almost unknown metal magnesium, and turned it over to the Sibley College laboratories for examination and test. The special purpose was to secure data for presentation to the Aeronautical Congress at the World's Columbian Exposition, at Chicago, in the summer of 1893; where the information which might be acquired relative to possible new metals and alloys, combining in high degree strength and lightness, would be peculiarly welcome.† The following is an extended account from which the published data were extracted and abridged:

THE tenacity of magnesium is low; but the metal is very light. The only experiments of any extent and importance with which the writer is familiar were made, at his request, for the purposes of this paper in the Sibley College laboratories, under the direction of Professor Carpenter, by Messrs. Barracleugh and Marks.‡ The following are the results of test of the commercially pure metal, in form of wire. The strength here obtained is but about two thirds that given by authorities generally, as quoted above:

PROPERTIES OF MAGNESIUM.
Specific gravity, 1.74; Melting point, 446 degrees F., 230 degrees C.

No. of Sample.	Diameter Inches.	Elastic Limit, lbs. per sq. inch.	Breaking Load.	Ductility per cent	Modulus of Elasticity.
1	0.433	8 800	23 800	4.2	2 040 000
2	0.433	10 780	22 050	..	1 880 000
3	0.442	8 400	20 900	1.8	2 060 000
4	0.435	7 090	19 500	2.5	1 830 000
5	0.424	..	24 800	3 1	1 930 000
6	0.432	..	22 500	2.3	....
Average	..	8 770	22 250	2.8	1 945 000
Best figures	..	10 780	23 800	4.2	2 060 000

Tests of *cast* magnesium have given results in our laboratories averaging about one half the above, and ranging from 9 640 to 13 685 pounds on the square inch. The figures given in the table as the best may, perhaps, be taken as those most closely representing the qualities of a pure metal of maximum density and purity, are better than can usually be expected in commercial work. They constitute a standard to which specifications may perhaps gradually approximate. The pure metal thus greatly excels pure aluminium in tenacity.

Copper and magnesium have not been found to alloy in our experiments, although much time and labor have been expended in the endeavor to secure such compositions.

Brass will take up a minute proportion of magnesium, but with no sensible useful result. The presence of the lighter metal produced neither accession of strength nor increased tenacity. In fact, in every instance the alloy was unsound and weaker than the brass itself.

Iron refuses to alloy with magnesium in any sensible amount, and, so far as our experiments indicate anything, the magnesium would seem to have no value either as flux or as a strengthening element. Magnesium and aluminium alloy with increase of strength of the resulting composition up to 10 per cent. Magnesium, when the alloy becomes brittle and valueless for constructive purposes. The following are figures obtained:

MAGNESIUM-ALUMINIUM ALLOYS.

No. of Sample.	Per cent. Magnesium.	Limit of Elasticity.	Tenacity.	Modulus of Elasticity.
13	0	4 900	13 685	1 690 000
14	2	8 700	15 440	2 650 000
15	5	13 090	17 850	2 917 000
16	10	14 600	19 680	2 650 000
17	30	..	5 000	....

The addition of magnesium to cast aluminium increases its tenacity by a percentage which exceeds five times that of the per cent. of admixture. The best of these alloys are ductile, and can probably be increased in tenacity fifty, possibly one hundred, per cent. by cold-working, pure, well-fluxed and sound samples, and the sustaining power thus carried up to lengths far exceeding those of "mild" steel.

The only recorded figures for alloys of copper with small doses of magnesium which have come to the knowledge of the writer, previously to those obtained in Sibley College work, are reported by M. Mouchel, but the composition is not given. The tenacities of these bronzes are substantially the same, it is said, as those found for silicium bronzes in similar form,—that of fine wire. They range from 50 to nearly 100 kilograms per square mm., of from about 70 000 to 140 000 pounds per square inch; where made for electrical transmissions—and with conductivities of from 95 to 50 per cent.; but they have been given 10 per cent. higher tenacities when it has been found practicable or desirable to employ alloys of conductivities as low as 20 per cent.§ The densities of these alloys are not stated; but if Mouchel's compositions change by single tenths of one per cent., the effect of magnesium on copper is obviously very considerable, both in reduction of density and increase of tenacity. The same authority elsewhere gives the conductivity of copper containing one tenth per cent. magnesium as 94.29.‖ The following is the table:

COPPER-MAGNESIUM ALLOYS.

Conductivity. Copper=I.	Tenacity. Lbs. on sq. inch.	Tenacity. Kgs. per sq. mm.	Proportion of Mg. (?)
95.16	73 659	51.80	0.001
81.60	86 869	61.09	2
63.89	106 892	75.17	3
58.01	115 718	81.37	4
51.43	135 767	95.49	5
50.61	108 740	76.47	6
21...	29 862	21.00	?

These give lengths carried as from 20 000 to 30 000 feet, or the equivalent of stee of 650 000 to 905 000 pounds tenacity.

* See papers of Professor Nichols and of Mr. Merritt: Trans. Am. Inst. Electrical Engineers, 1890–91.

† See a paper on "Materials of Aeronautic Engineering," by the writer, in Transactions of the Aeronautic Congress; also in "Aeronautics" for March, 1894. In these studies all materials were compared by deducing from the data obtained the length of their own substance which each metal could sustain. Steel, for example, when of 75 000 pounds tenacity would carry about five miles of straight, suspended bar.

‡ Since published in the Sibley "Journal of Engineering," January, 1894.

§ Reports on the Paris Exhibition of 1889, Vol. iv., p. 233.

‖ Ibidem, Vol. iv., p. 232.

Comparing magnesium with other substances, on the basis of combined strength and lightness, the length of a prism of uniform cross-section which the metal can carry suspended vertically is probably the best standard; it was this which was adopted in the paper above referred to in the endeavor to ascertain the relative value of metals and other substances for aeronautical construction. Taking the tenacities of magnesium as from 22 000 to 32-000 pounds per square inch, it would sustain from 30 000 to 40 000 lineal feet of its own substance, or the equivalent of steel of 100-000 to 150 000 pounds tenacity. The latter is a tool steel and only exceeded by the wire-drawn and rolled steels of exceptional fineness and thinness, which sometimes attain tenacities of 300 000 and even 400 000 pounds per square inch, and are capable of sustaining from twenty to twenty-five miles of their own material. Machinery now built of open-hearth or Bessemer steel of common tenacities, if constructed of these materials of exceptional lightness and strength, would be correspondingly reduced in weight. Thus, the lighter marine engines seldom fall below 200 pounds per horse power; although torpedo-boat machinery and the engines of fast steam yachts sometimes fall to one-half or even, in rare instances, to one-fourth these figures. Were it practicable to construct such machines of aluminum, their weights would be but little reduced. Could they be made of magnesium, the weights would be reduced about 50 per cent. But, on the other hand, could the ultimate tenacity of absolutely pure steel in the form of fine wire or watch-spring be used, the weights would become from fifty to fifteen pounds per horse power. The maximum molecular tenacity of the finer steels is probably not less than 400 000 pounds per square inch, and when we shall be able to so purify and compact our metals as to attain this maximum, steam engines may be constructed of standard design, similar to those to-day employed, and not exceeding ten or twelve pounds weight per horse power; and exceptional designs, such, for example, as those adopted by Maxim and by Langley—who have actually introduced the finer steels in strongest forms, and who have already thus brought down the weight of engines alone to ten and six pounds per horse power—would probably give us weights as low as three or five pounds per horse power. Magnesium has thus no promise of competition with steel, in general construction; but its place may nevertheless be very probably found in bearings and cast parts, even where the running parts are steel.

It curiously happens also that some of the woods may, for such parts as they may be adapted to, compete not only with magnesium and its possible alloys, but also with these fine steels. Professor J. B. Johnson finds tenacities of 20 000 to 30 000 pounds for woods weighing one-twelfth as much as steels, or where strengths and lightness combined are compared, having values equivalent to steels at tenacities of a quarter of a million pounds and upward.

It is thus evident that until we know more than at present of the gain to be secured by alloying other metals with magnesium, it can only be said that it seems a possible rival of aluminum.

The fact that we find aluminum alloyed with small percentages of titanium and of other metals, gaining enormously in strength, without serious loss of its peculiar lightness—sometimes doubling its value on the above scale of comparison, and becoming the equivalent of steel of 150 000 pounds tenacity—renders it extremely possible that the same or greater effect may be found to obtain with magnesium, and that our most promising field of investigation is now among its alloys. Both aluminum and magnesium alloys may have important applications in the construction of electro-dynamic machinery. It is known that the conductivity of the former alloyed with copper, titanium and silver, is very high. Dynamos constructed in the shops and laboratories of Sibley College, in which these alloys have been employed, or the pure metal used, have been already found to possess advantages where lightness is essential, as for example, and especially in aeronautic work. The most successful dirigeable baloons to date, those of Reynard and Krebs, have been driven by electricity.

* * *

We have received the first copy of *Hardware and Supplies*, dated, March, 1896, which contains 40 pages and cover, 6¾×9¾ inches, and presents a good appearance, the cover resplendent in red and black, in the latest style of art. It should meet with a warm reception by the trades which it represents. It is published by the Hardware & Supplies Publishing Co., Cleveland, O., at $1.00 a year.

EFFICIENCY OF BOILERS AND ENGINES,—1.

BOILERS.

Theo. F. Scheffler, Jr.

The time is not distant when the evaporative efficiency of steam boilers will be calculated from the total number of British thermal units. How can we determine this efficiency? This is determined by knowing the number of units of heat that a pound of coal and a pound of combustible will give out when burning under perfect conditions, and the number of heat units that the water evaporated has received. In doing this, the heat that goes up the chimney should not be deducted from the possible heat of the coal, as is sometimes done, for different boilers allow different amounts to escape. It should be the function of a boiler to reduce this heat as much as is consistent with the temperature of the steam. Supposing we had a pound of coal that would give out 14 675 B. T. U., considering the coal absolutely dry, and that from ordinary conditions we have 4.7 per cent. of ash; then, to find the total heat in one pound of combustible, we would divide 14 675 by 100−4.8, therefore,

$$\frac{14\,675}{100-4.7} = 15\,398 \text{ B. T. U.}$$

Then the efficiency based on combustible would be,

$$\text{Efficiency} = \frac{\text{Heat usefully absorbed from 1 lb. of combustible.}}{\text{Heat value of 1 lb. of combustible.}}$$

The mechanical efficiency of a boiler is found thus: The percentage of efficiency of any boiler is the total amount of heat utilized by the boiler in British thermal units. That part of the heat that is not utilized is wasted and carried off into the chimney, or by the poor construction of the boiler. Of course, this is not always the case, because sometimes feed-water economizers are placed in the connection between the chimney and boilers, and the result is the feed-water is fed into the boiler at a much higher temperature than is done ordinarily without the economizer.

We give here as an actual result obtained from a test of a 200 HP. water tube boiler, 14 581 B. T. U. per pound of combustible. Heat utilized by the boiler is 11 592 B. T. U. The per cent. of efficiency is obtained by dividing 11 592 by 14 581, which gives 79 5 per cent. Several other cases at hand give 76.75, 73.6, 77 and 74 per cent. efficiency, all water-tube boilers. Another way by which the efficiency may be calculated is by the number of pounds of water evaporated per cent. of theoretical figures. As ordinarily we can obtain about 14 500 B. T. U. on an average from one pound of carbon, and consequently if all of these heat units could be utilized, or obtained in one pound of coal, we could evaporate about 15 pounds of water per pound of coal. Therefore, taking a boiler that has evaporated 11.25 pounds of water per pound of combustible from and at 212 degrees, we divide 11.25 by 15, which gives us 75.03, which is the actual efficiency per cent. of theoretical, assuming 14 500 heat units is obtained per pound of combustible. The above result was obtained from a water-tube boiler in actual practice.

Some other items of interest connected with the same test may here be found of general interest. Quality of coal, chestnut anthracite, wet and dry:

Duration of test	21.5	hours
Coal thrown on grate	16 388	pounds
Surface waste in coal	1 207.8	"
Dry coal thrown on grate	15 180.7	"
Wood used for kindling	462	"
Cotton waste to start fires	72.5	"
Ashes and residue	3 305	"
Combustible in coal consumed	11 875	"
" = wood ×.36	166	"
" = cotton waste	72.5	"
Total combustible consumed	12 114	"
Heat units apparently received by boiler	134 410 015	
Heat units actually received, water allowed for	130 176 100	
Heat units received per lb. of combustible	10 745.48	
Water evaporated per pound of combustible from and at 212°, pounds	11 127	
Apparent efficiency per cent.	74.18	
Heat units required to dry coal	1 497 793	
Water actually evaporated from and at 212° Fahr. per lb. of combustible	11.255	

A boiler, in order to give the most economical results, will deliver to the engine 75 per cent. of all the energy in the combustible, or say 10 875 out of a total 14 500 heat units, or allowing about 8 per cent. for ashes 10 000 heat units for each pound of coal

burned. Ordinary boilers will not give this probably, or an average not more than 65 per cent. of the theoretical figure, which is 14 500 heat units for a pound of pure carbon. The 10 000 heat units represent 7 720 000 foot-pounds of energy, which, if all utilized by the engine, would give 3.9 horse power for one hour, or at the rate of 26 pounds of coal for each hourly horse power. The .26 pounds is all theoretical, for by the greatest economy in steam engines yet accomplished, the cost of a horse power has not been brought below 1½ pounds of coal per hour, except on very rare occasions, which is about 17 per cent. of the energy delivered by the boiler, while the average engine was 3½ pounds of coal per horse power per hour, and discharges 93 per cent. of the energy delivered to it. The greater part of this loss is in the latent heat of the steam which is exhausted into the atmosphere or condenser.

To a certain extent there is more economy obtained with a condenser than without one. Still, the fact remains that many ordinary engines use about four times as much steam for the same power as required by the most economical engines. This is caused by large clearance, poorly designed ports and unbalanced valves, and general bad construction of the wearing parts of the engine. The best engine is the cheapest in the long run. As already mentioned, the amount of heat a pound of carbon will furnish by its combustible is about 14 500 thermal heat units. And in the best of boiler performance only 10 875 of these units can be utilized in evaporating water into steam, neglecting the ashes. If the water is heated to enter the boiler at 212 degrees and is simply converted into steam at the above temperature, we obtain a performance of $\frac{10875}{965}$=11.2 pounds of water evaporated by a pound of coal. The latent heat of steam at 212 degrees is 965 heat units. Latent heat is that which is insensible to the touch of our bodies and incapable of being detected by a thermometer.

When a body passes from the solid or liquid to the gaseous state, its temperature during the operation remains stationary at a certain boiling point, depending on the pressure of the vapor produced; and in order to make the evaporation go on, a quantity of heat must be transferred to the substance evaporated. Another example is, if the water is fed into the boiler at 100 degrees temperature and evaporated at 75 pounds, we have 320 degrees, which is the temperature of the steam; therefore, 320°−100°=220° thermal units; the latent heat of steam at 75 pounds is 888 thermal units, and adding 888 to 220 gives 1 108 thermal units, which is the total heat minus the feed-water degrees. We then divide 10 875 by 1 108, which gives 9.8 pounds of water per pound of coal. Coal has a certain amount of impurity which we will call non-combustible; frequently as much as 15 per cent. With this proportion, 1 pound of coal as above would only evaporate 85 per cent. of 9.8 pounds, which is equal to 8.3 pounds of water per pound of coal. In view, then, of this performance for the best class of boilers, a duty of 7½ pounds of water per pound of coal under ordinary condition is not bad practice. Of course a good feed-water heater will improve matters considerably by putting water into the boiler at a higher temperature.

The following table (No. 1) shows the state of case. All above double horizontal lines are theoretical conditions, but in some instances the best boiler will give a little more than here shown per pound of combustible, when the ash is allowed for:

TABLE NUMBER 1.

	Temp. of feed water 212 deg. Evap. at 212 deg.	Temp. of feed water 100 deg. Evap. at 320 deg., corresponding to 75 lbs. boiler pressure by gauge.	Temp. of feed water 200 deg. Evap. at 331 deg., corresponding to 90 lbs. boiler pressure by gauge.
	Pounds.	Pounds.	Pounds.
Theoretical conditions, 1 lb. of pure carbon.....	15	13	14.3
1 lb. of pure combustible under best boilers.....	11.2	9¾	10 7
Best coal under best boilers, 8 per cent. non-combustible....	10.3	9	9.9
Fair coal under best boilers, 15 per cent. non-combustible....	9.8	3¼	9.1
Fair coal under fair boilers, 15 per cent. non-combustible....	8.3	7	7.7
Poor coal under fair boilers, 30 per cent. non-combustible. ..	6.8	5¾	6.3

Another method for heating feed water is obtained by using an economizer. The economizer is composed of a series of cast iron pipes. The pipes are placed vertically in the main flue, by which the heated products of combustion are conveyed from the boiler to the chimney. These pipes are slightly under 4 inches diameter inside and $\frac{5}{16}$ of an inch thick, measuring $4\frac{5}{16}$ inches diameter outside, and are usually about 9 feet in length, connected together by top and bottom boxes. The feed water is passed through these on its way to the boilers, and thus absorbs a large proportion of the waste heat stored up in the furnace gases, the saving in fuel thus effected varying according to the temperature of the escaping gases from 10 to 15 per cent. of the total fuel consumed. The temperature of the gases is reduced on an average from 650 degrees Fahr. on the boiler side of the economizer to 350 degrees when leaving the economizer chamber to pass into the chimney stack; and the temperature of the feed water is increased on the average about 150 degrees, *i. e.*, from 100 to 250 degrees, or, when introduced comparatively cold, say at 62 degrees up to 212 degrees. It is not advisable to cool the gases below 400 or 350 degrees, and in a large number of instances the feed water is heated up to 300 degrees and as high as 316 degrees in economizer.

Supposing we had 300 degrees for feed water, and evaporated into steam at 75 pounds pressure, how many pounds of water would we evaporate per pound of coal, assuming we obtained 10 875 thermal units? Temperature of steam at 75 pounds is 320°−300°=20°; latent heat at 75 pounds is 888.5°×20°=908.5° total heat minus the temperature of the feed water. Therefore dividing 10 875 by 908.5=11.9 pounds of water evaporated per pound of coal. The 320 degrees is the boiling point of water at 75 pounds pressure by gauge, or 90 pounds absolute pressure, or from a perfect vacuum and 888.5 thermal units are required to transform one pound of water into steam at that temperature. The total heat as above calculated is not strictly correct, as a small allowance should be made for the specific heat of water. The percentage of gain at any pressure by increasing the temperature of feed water may be found by the following formula:

$$\text{Gain per cent.} = \frac{100\,(T-t)}{H-t}$$

Where H=total heat of steam at boiler pressure.
" T=temperature of feed water after heating.
" t= " " " " before "

Example.—A boiler working at 100 pounds pressure is supplied with water at 100 degrees Fahr. from a condensing engine. When passed through the economizer the temperature of feed water is raised to 250 degrees. What is the gain in per cent.? Total heat in steam at 100 pounds pressure=1216.5=H.

Temperature after leaving economizer=350°=T.

Temperature before entering economizer=100°=t.

Then

$$\frac{100(T-t)}{H-t} = \frac{100\times(250-100)}{(1216.5-100)} = \frac{15\,000}{1116.5} = 13.4 \text{ per cent gain.}$$

Probably the most economical place to locate the economizer is in connection with large power plants, where from 1 000 to 3 000 horse power is daily required. For small plants the gain should be proportional. The reason is that small plants are seldom furnished with a large chimney, or the brick connection that is required from boiler to stack for location of economizer. It is not usually furnished because it is much more expensive than the ordinary sheet-iron connection. Sometimes a lack of room is also sufficient reason for not installing the economizer with small power plants.

* * *

THE HURLBUT & ROGERS SHOP.

The shop of Hurlbut & Rogers, at South Sudbury, Mass., contains many interesting kinks, as do most of the New England shops (which isn't saying that they have a monopoly patent on kinks either), a few of which we show with this.

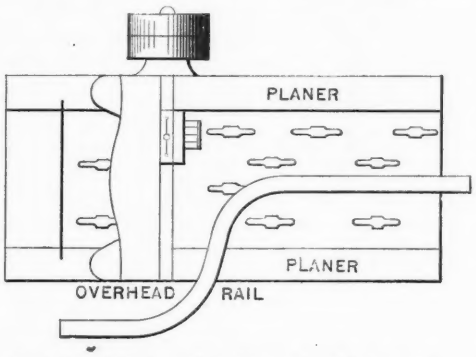
The little truck shown in Fig. 1 is a handy affair and appreciated by the men who have to move their heavy cutting-off machines for shipments. The construction is shown fairly well, the wheels being about six inches in diameter and the L shaped end

pieces probably 4x4x¾ inches. This is used after the machines are mounted on skids (as indicated in cut, which shows the skids

in place) the machine being raised until the truck can be rolled under to about the center, so as to balance well for handling, when the machine can be rolled round the shop without much difficulty.

The shop is also well equipped with appliances for handling materials, and though most of the devices are "home made" they handle the work in good shape. Post cranes and overhead trolley rails are liberally provided, and the latter are so convenient that it seems strange they are not used more extensively.

Taking a small planer, for example, the rail need not be over ten or twelve feet long, for if bent to a double curve, like a straightened out letter S, with one of the straight ends over the planer bed and the other swung out to one side of the planer, whichever is most convenient, and with this arrangement as shown in plan view by Fig. 2, gives a good control of work for this tool. Of course a hoisting block and trolley wheel is placed on the rail as desired, one block serving several rails if necessary in small shops, as it is seldom that more than one machine in three needs its services. The handling of the block from rail to rail is, of course, an objection, but they can be connected at slight expense.



One of the features of their cutting-off machine is the accelerating motion used, which increases the speed as the tool advances toward the center, maintaining the desired cutting speed regardless of the diameter of the work. This is a step in the right direction and tends toward economical results, and has been adopted by at least one maker of lathes which will be mentioned later. C.

* * *

DIRECT-READING MICROMETER GAUGE.

We illustrate on this page a direct-reading micrometer, which has been devised by Mr. Ciceri Smith, of Edinburgh, and is supplied by Messrs. Smith, Son & Co., of 219 High street, of the same city. The difficulty of reading a micrometer of the ordinary type in a dull light is well known, and as a short mental calculation is usually required to arrive at the proper result, an error is very liable to slip in here, especially when the instrument is only used occasionally. Thus in the ordinary form of caliper gauge the screw is cut with 50 threads per inch, and the shank is divided so that each division represents $\frac{25}{1000}$ in., whilst each division on the divided edge of the thimble represents $\frac{1}{1000}$ in. In reading the instrument, therefore, the number of divisions shown on the shank have to be multiplied by 25, and added to the reading on the edge of the thimble. As will be seen from Fig. 1 above, Mr. Smith's instrument is of the caliper type, with the addition of a set of registering dials, as shown. A section through the frame of the instrument is shown in Fig. 2, whilst the screw and its attachments are shown separately in Figs. 3 to 8. The threads are 50 to the inch. They are protected from injury by a thimble U which is rigidly fixed to one end of the screw, and turns with it. A second thimble W is placed over that already mentioned, and is fitted with a knurled end. This outer thimble drives the screw through the friction of the spring shown in Fig. 5, and hence it is impossible to strain the screw, since as soon as the pressure becomes too great the spring allows the thimble to slip. The connection of the spindle to the registering wheel is effected by means of the stop shown on the unthreaded portion, Figs. 3 and 4. This takes into a slot on a sleeve, on which is mounted the thousandths wheel D, Fig. 8, which in turn drives the hundredths and tenths wheels F and H through the intermediate pinions G and E. These latter have a step-by-step motion, as in an ordinary counter. The cover of the cage is pierced to show the numbers on the dials, as represented in Fig. 1, but these openings are covered with glass, with a view to excluding dust and dirt from the mechanism. At the same time the metal cover is countersunk around the orifices, so as to bring the figures as close up to the glass as possible, and thus avoid shadows on them. The different wheels operate in the following way: The large wheel D, mounted on the shank of the screw with which it rotates, drives the pinion E, which has only half the number of the teeth, and thus rotates twice whilst D revolves once. The figures on D, it will be seen, are repeated, so that for each revolution of the screw, it shows in succession 20 figures. As the pitch is $\frac{1}{50}$ in., each figure represents an advance of $\frac{1}{1000}$ in. As E has only half the number of teeth, every time the screw is revolved half a turn, the "long teeth" engage with the teeth on the second registering wheel F, and move it through one division, representing $\frac{1}{100}$ in. Motion is conveyed from F to H by the idler G, also fitted with long teeth, which turn H through one division for every revolution of F. The figures on H therefore denote tenths of an inch. The device has also been fitted to micrometers of the bar type. The registering device is fitted in this case on the sliding head, which latter is in the first instance adjusted to one of the divisions engraved on the bar which are cut at intervals of $\frac{1}{10}$ in. The rule is read through windows cut in the head as shown, the figures, as it will be seen, being suitably engraved. Thus whole inches and tenths are obtained direct, whilst the reading of the micrometer giving the hundredths and thousandths is registered at openings on a line with the windows already referred to. The registering mechanism is similar to that used in the caliper gauge. Mr. Smith's gauges are extremely convenient to use, and those we have examined are admirably finished in all details.—*Engineering*, London.

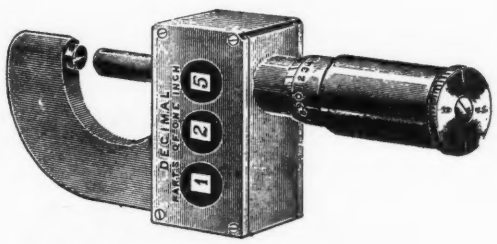
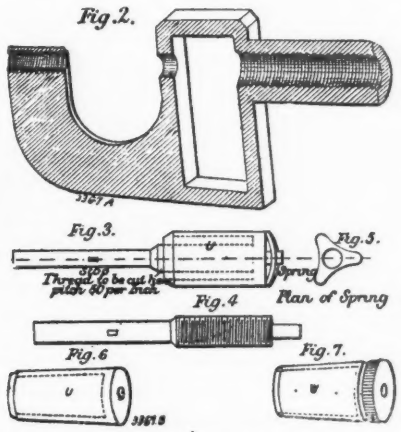


FIG. 1.



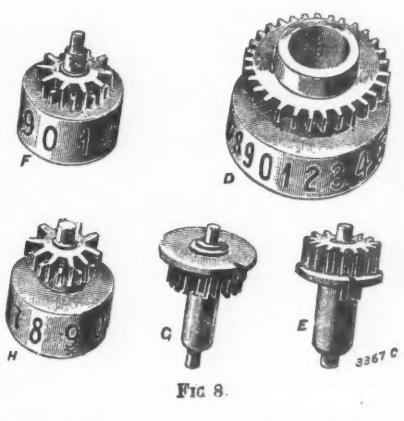


FIG 8.

* * *

CONTRACTING RING GAUGES.

B. F. SPALDING.

In the February issue of your paper a correspondent refers to a clipping from an English paper, which is a translation from a German periodical, of a paragraph which describes a method of contracting the size of a hole in a piece of metal. The scheme is to heat the piece to a bright red, and dip a part of it in water, so that the part which surrounds the hole for half its length may be quickly cooled. The correspondent intimates that, contrary to the statement which is made in the article referred to, the hole will be smaller in the part which is in the water than it will be in the other part.

There is nothing new in this practice; it is common, and was described in American and foreign journals a dozen years ago, to my certain knowledge. There is involved in it a behavior of steel which is sometimes accused of being tricky, when it is really acting in an orderly and law-abiding manner. Taps and reamers sometimes break because people will not learn not to make the

cooling taper off, instead of stopping the steel short and suddenly in the water, and shrinking it suddenly below the water line, so that when it comes to shrink above the water line, the piece cracks right there, because the two shrinkages set up a great stress, like the action of two levers prying in opposite directions at that point.

The practice of contracting holes by shrinking a part in water was very likely not founded upon a theory, for it is too generally in use by persons who do not hunt for theories. It is probably one of those things that discover themselves, like the use of a lever, without any effort on the part of the discoverer. When the matter is investigated, however, the cause of the action which takes place is easily seen, and it will also be readily perceived that it is only under unusual circumstances that the result will be to make the part which is quenched in the water become the smallest. It can only occur when there is not enough of the piece dipped into the water to influence the hot part.

Let us suppose that the hole is in a ring and that the ring is heated to a bright red, and this process has enlarged the diameter of the hole. How much? Just as much as a piece as long as the diameter of the hole would expand if it was heated a bright red. As it is easier to imagine the effect of heat upon a straight piece of steel as wide as the depth of the hole and as long as its diameter, than it is to conceive of how a hole will be affected, it is better to use the straight piece for illustration, as the effects are similar on each. The piece will increase in length by heating, and recover its normal size by cooling, the same as the diameter of the hole.

If the piece be cooled from a bright red heat and has nothing to hinder it from contracting freely, it will get to be nearly as short as it was before it was heated; but when a part of it is cooled at a time, it has something to prevent it from contracting freely. Suppose the piece to be three inches long, two inches wide, and thin, say a quarter of an inch thick; if it is any thinner it will be apt to warp enough to spoil the experiment. This piece will expand about .05 inch in heating, and shrink the same, nearly, in cooling. Now instead of dipping it all over in the water to cool it, it is only dipped in one half of its width, which is one inch, and this inch, in cooling, tries to contract .05 inch, but its tendency to contract will be resisted by the other part, an inch wide, which is out of the water and, retaining its heat, does not shrink as fast, but the power of contraction exerted by the part which is in the water is so great that it forces the hot part to shorten while it is hot. It exerts its greatest stress close to the water line, and gradually less as the distance increases above the water, and the lessening is in proportion to the conductivity of the metal and to its mass. A thick piece would be affected at a greater distance than a thin piece, and a metal of good conducting capacity at a greater distance than one of less.

Besides the shortening of the upper part of the piece, which is forced upon it by cooling the lower part, there is also the shortening occasioned by its natural shrinkage in cooling, so that it is nearly as much shorter after it is cold than it was before, as the amount it got shortened up by the contraction of the part in the water, but not quite; for the part in the water is not as short as it would have been if the hot part had not opposed its shrinking, and now it is cold, it opposes the full shrinking of the hot part. To overcome this trouble the operation must be repeated, putting the other side into the water.

Of what use is this process? It is sometimes of value in the hands of an experienced man, to decrease the size of ring gauges which have become worn by use. But the best experienced skill cannot prevent them from becoming bell muzzled in many cases; and the efficiency of the process is lessened by every repetition. Plug the hole in a ring gauge before dipping it for shrinkage, and make the cooling for hardening a subsequent process, in which arrangements should be made to circulate water through the hole and thus cool the ring from the inside. Dies for rivet-making machines are hardened best in the same way. The reason why such things harden bell mouthed is because the ends cool and "set" while they are yet expanded by the internal heat, which their power of contraction is insufficient to overcome.

Although it is dangerous, especially on small pieces, to stop short in dipping them into the water, it is not probable that any trouble will arise from thus treating short, chunky pieces, and in cooling for shrinking, that cooling medium is the best which will quickest abstract the heat.

Oil, if it cold enough (zero for coal oil), may often be used to the greatest advantage in hardening. When oil is used, saw dust should be kept on hand always in a convenient receptacle, in which the hardened parts may be cleaned with a brush. With these inexpensive conveniences at hand, oil may be used as neatly as water, and the disagreeable features attending it will be obviated.

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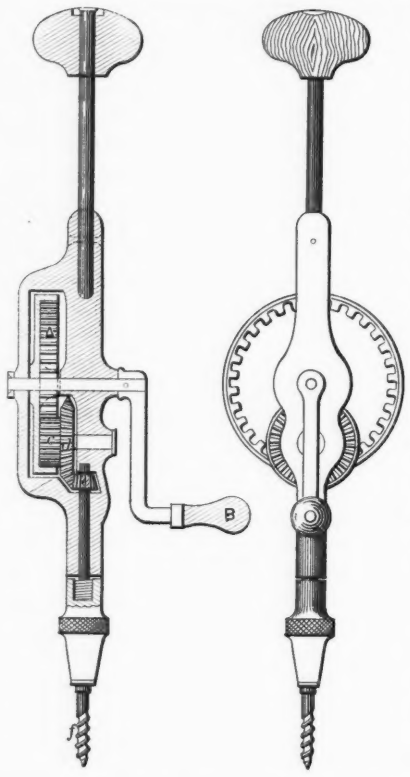
HIGH SPEED DRILL.

This is a plan for a high speed drill, especially designed for pattern makers and cabinet makers.



The main or driving gear A, is an internal gear, fastened to driving shaft and driven by handle B. Into this, meshes the pinion *e* which also carries the bevel gear *d*. This meshes into and drives the bevel pinion *e*, this being fastened to drill spindle as shown. The gearing shown gives a speed ratio of crank to drill of 16 to 1, which is high enough for almost any kind of work. The spindle can be fitted with any kind of chuck desired.

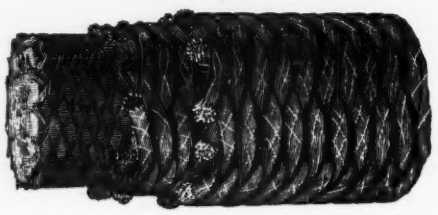
* * *

Our interesting London contemporary, *Industries and Iron*, is publishing a fine set of Collotype plates, 11x13 inches, of eminent engineers and scientists. Among them so far issued are Lord Kevin, James Howden. Dr. John Hopkinson, W. H. Preece, James Riley, Sir James Kitson and others, and all are well worth preserving.

* * *

SEMI-BRONZE PACKING.

This is the name given to a new high grade packing for engines and pumps, manufactured by the New Jersey Car Spring & Rubber Co., Jersey City, N. J. The core, which is the foundation of the packing, is a lubricator reservoir, and is composed of loosely spun asbestos thoroughly saturated with high grade cylinder oil, pressed into the desired shape and coated with pure foliated graphite. The covering consists of alternate strands of hemp and asbestos, loosely spun, each braided over with an open work of very fine brass wire. All of the strands are very loose and fluffy, so that they will readily soak up all oil and hold it, and the braiding of the wire being quite open, permits the oil to flow readily from the fibre and carry along with it the graphite to the piston rod when heated. Beside serving to hold the soft fluffy materials together, the wire adds to the lasting qualities of the packing, both by its own resistance to wear when properly lubricated, and by reason of its protection of the fibres from being blown out of the stuffing-box by steam or water pressure. This packing is used in the same way as common fibrous packings, and needs no special handling or care.



SEMI-BRONZE PACKING.

The value of semi-bronze packing has been fully proved by actual practice in hard service. It has given entire satisfaction wherever put in, both as to its lasting qualities and the bright appearance of the piston rods. It is the result of years of experience of a practical and well-known engineer and pump builder. It is put up in twelve-feet lengths, each length in a separate box,

labeled, and sells at a popular price. Two brands are made, viz, "Gilt Edge" and "Combination."

Circulars and further information will be furnished on application to the makers.

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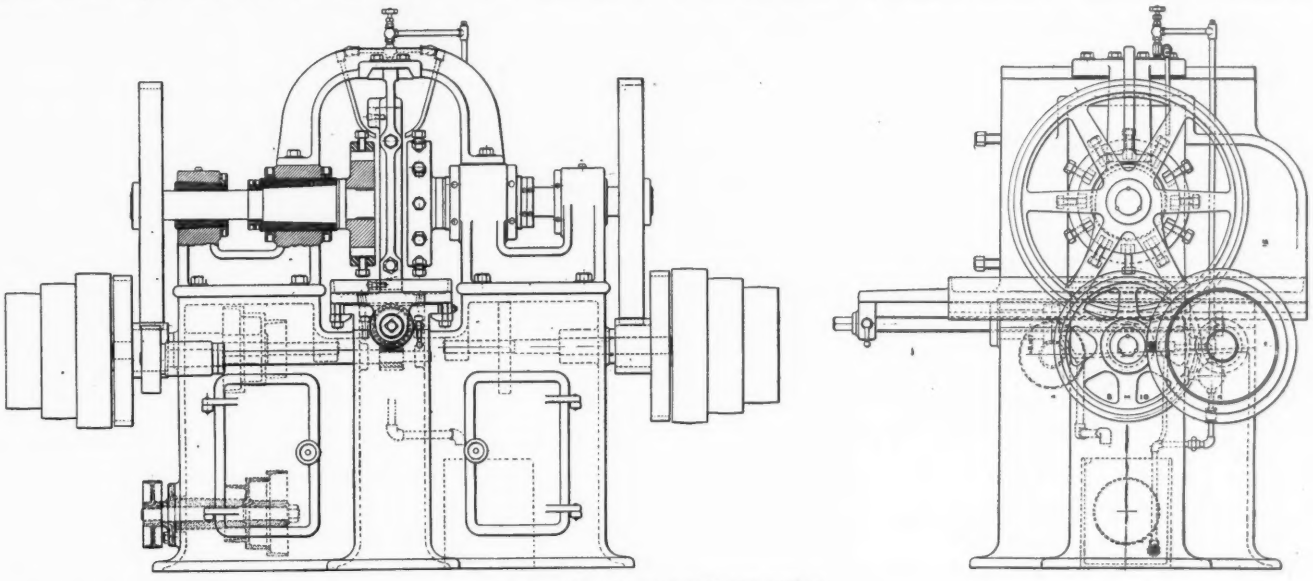
DOUBLE HEAD SPECIMEN MILLER.

The illustrations show the working drawings of the Riehle Double Head Specimen Miller, designed by Mr. H M. Norris, for



RIEHLE DOUBLE HEAD SPECIMEN MILLER.

the rapid milling of flat test pieces, and will mill both sides of thirty-two ⅜ inch thick specimens at one setting. Each cutter head is fitted with twelve tools and is driven independently in the ratio of 1 to 30. The spindles have a longitudinal adjustment of 2 inches and run in bronze boxes provided with convenient means of taking up wear. The driving cones have three steps for 3½ inch belts, and are geared to give a cutting speed of 14, 19 and 24 feet per minute. The table, or specimen holder, has a lateral movement of 24 inches, and will take in specimens up to 19 inches in length and from ¾ to 4 inches in width. It is provided with automatic feed of nine changes, varying from .25 to .75 inches advance per minute.

The machine is furnished with pump and settling tank, and is arranged with suitable channels and strainers for maintaining a continuous oil or water supply; also with tool grinding attachments for re-sharpening the tools without removal from chuck.

The principal dimensions are as follows: Extreme height, 4 ft. 10 in.; extreme width, 4 ft. 5 in.; extreme length, 6 ft. 10 in.; weight, 4,500 lbs.; shipping weight, 5,200 lbs. It is made by Riehle Bros., Testing Machine Co., Philadelphia, Pa.

* * *

A NEW PIT LATHE.

This pit lathe is adapted to a great variety of work which can be done in a rapid and accurate manner. The face plate is 68 inches in diameter. The tools can be set in far enough towards the center to turn 36 inches in diameter and the cross rails moved far enough back to take in a diameter of 18 feet. By a use of a heavy bar in the compound rest, as is common on boring mills, even smaller than 36 inches could be turned.

The four turning tools have power angular feed. The boring bar can be used simultaneously with the turning tools, and the five tools working together can bore a pulley, turn the face, edges, and the rest in quicker time than can any other form of machine designed for such work. There is an outward support for boring bar, so the bar cannot sag of its own weight, but is not shown in this cut.

The angular adjustment of the turning tools is valuable when turning the grooves in rope drive wheels, as whatever angle it is desired to give these grooves can readily be obtained.

The advantage of a pit lathe for large pulleys is that they are said to be turned truer than when turned on their centers. Besides working on rope drive wheels, fly-wheels, pulleys and gears, the lathe has been used with good results in boring large cylinders. The internal gear of face plate is of steel, machine cut. The ratio of gearing is 160 to 1. There is a uniform ratio of speeds from .35 revolutions per minute to 47.66 revolutions per minute.

It is designed by the Gleason Tool Co., 25 Race street, Rochester, N. Y.

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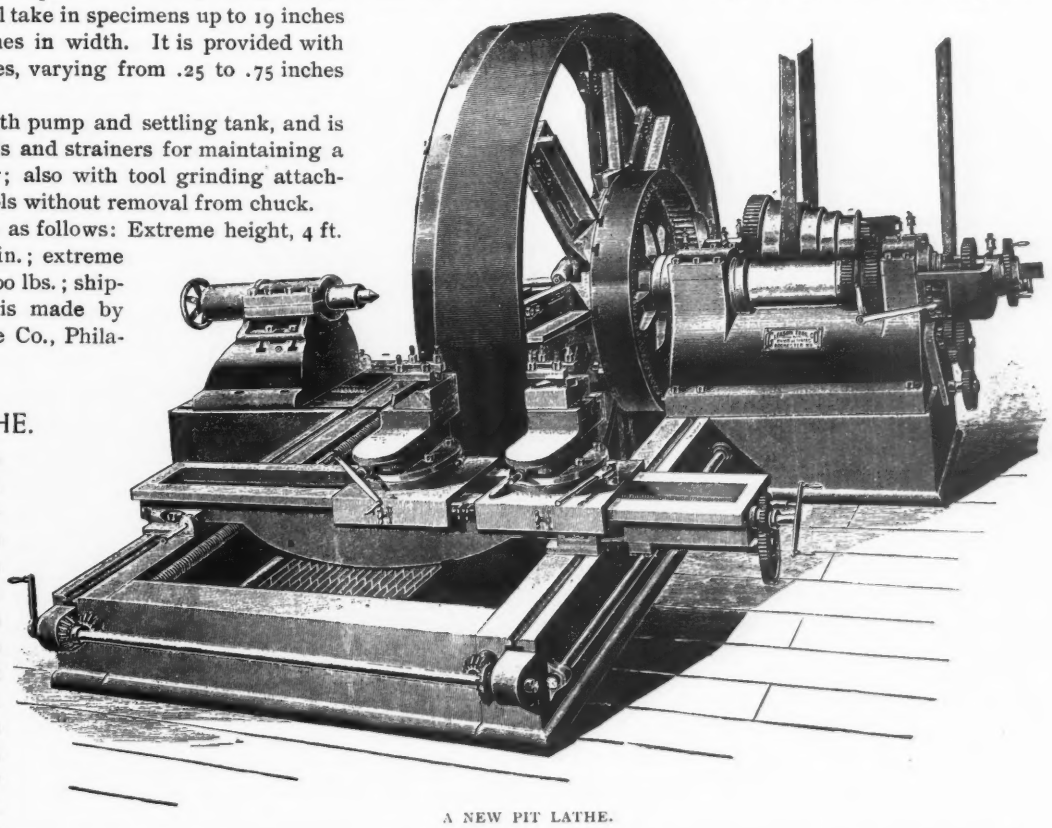


A NEW PIT LATHE.

It is proposed by R. H. Plass, of Brooklyn, N. Y., to have a system of automatic whistling buoys, of his invention, to not only line the coast, but also to mark the pathways across the big pond. They are to automatically produce their own gas or electricity for lighting, and compress the air for their whistle, as well as provide shelter for shipwrecked men, and to be connected by telephone and telegraph. Every tenth or twentieth buoy is to be a double-decked affair, with the upper story arranged for three meteorological service men, who are also to be equipped with life boats and rafts—be life savers, in fact. Although very desirable, there

seems to be too much "automatic" about the scheme to work out in practice.

* * *

BURGLAR PROOF SAFES.

We recently went into the office of a man who used to make safes, but who has reformed and now builds machine tools and other things, and were surprised to see these signs:

> Here is the key.
>
> Don't spoil the safe.

and

> The combination of this safe is
>
> * * * * * * *
>
> Don't use your jimmy.

"You look surprised," said the ex-safe maker. "Well, I'll tell you; we don't keep any money here (haven't much anyhow) but we got tired having to pay for repairs on safes. Four times in one year we had to pay numerous dollars to get the safes fixed so we could shut the doors after they had been blown, jimmied and drilled open; they don't bother us now." And these are burglar proof safes.

* * *

NOTES FROM NOTOWN.—II.

DRAFTSMEN—PIECE WORK—SPEED OF MACHINE TOOLS—KEEPING CLEAN.

ICHABOD PODUNK.

I note Mr. Griffin's exception to my statement concerning the draftsmen of a certain large tool works, which by the way is one of the largest and oldest in this country, and while I admit there must be something wrong in the drawing office, it is certain that if the draftsmen had a fair knowledge of shop work that many of the common errors would be avoided. Mr. Griffin voices an idea which I have often expressed when he advocates the frequent consultation between draftsman and shopman. It is not only advantageous to both parties, but is especially valuable to the employer. This does not, however, entirely replace the shop experience, as it places the draftsman in the hands of the shopman, who may or may not be the brightest of his kind. As in other things, a personal knowledge from actual experience is to be preferred, and a few years in a good shop is an education that will help any draftsman.

I cannot help mentioning a case that came to my notice some time ago. A bright young fellow with a taste for mechanics went through Cornell and graduated with honors and was immediately offered a good position. A year's work, however, convinced him that he needed shop experience; consultation with foremen was not enough for him, he wanted the experience himself. He then entered a good shop as an apprentice, worked his ten hours a day for about three years, and is to-day one of the brightest M. E.'s in the country. He consults with the fore men and workmen, but he doesn't have to depend on their judgment in the matter.

It has always been a hobby of mine that the ideal mechanical training was to have boy or young man spend three or four years in the shop, then go to college, and he is prepared to study just the portions he will need later, and none of the "frills" which are too often a part of the college course, but which will never be used in after life. Then, too, a chap at this age will have left some of his coltishness behind in the shop, will attend to business and be less apt to indulge in the deviltry which is too often called fun when done by college boys, but which is a breach of peace when the participant happens to be of the common sort.

Mr. Chappell certainly makes out a strong case and proves to his own satisfaction at least, that piece work is the only panacea. Theoretically it is a fine system, but in my personal experience I cannot recall a case where it has worked satisfactorily, the friction between employer and employed being at all times objectionable. As Mr. Rogers said of day work last month, "It would be a perfect system if both employer and employee were honest," and his experience bears out my own.

The lack of good mechanics is a somewhat different question, but bears closely on the piece-work system in some respects, Piece-work and its attendant low price per piece is only possible where men do one class of work day after day, and it is just possible that the men who couldn't make fast time on the job Mr. Chappell mentions had been doing different work all their lives, and further that their letters of recommendation were written with reference solely to this class of work. The men are surely not to blame for not knowing how to do work they never had a chance to do, and while it is easy to say that they ought to have secured another job, so as to get a variety of work, it must be remembered that this means lower wages at the beginning at least, and few can afford to work for from $6.00 to $8.00 per week, even for experience, when they can possibly make $12.00 or $15.00 by hard work at piece work. Perhaps they might make more, but they know better.

Of all the neglected things about shop work I believe the speed of tools is the worst—even worse than the scrap pile, which sometimes grows till you can't see over it. The speed of tools depends on the ideas of the foreman and those of the men, and these ideas depend largely on the shop in which they imbibed the first supply of mechanical knowedge. Our Mr. B. has pretty good ideas on this, and stands about midway between the "crawlers" and the "jammers," of which we have several in town, but none of the latter in this shop, though there are plenty of the former.

The man next to me runs a 16-inch lathe, which is well built, is very rigid and can stand a good cut—one of Mr. Ridgway's "pullers," but the man was evidently brought up on a light lathe and hasn't discovered the difference. Mr. B. came to him yesterday and said pleasantly: "Better speed up a little, Jack; that lathe can pull a heavy cut and pull it twice as fast as you're running. Let's see," said he musing; "your work is about 4 inches in diameter—call it a foot around it—and you're running it twelve turns a minute," as he timed the lathe. "Only 12 feet a minute for cast iron; you can just about double that with this lathe; it's good and heavy and will stand it."

So Jack speeded up a little, but his face wore a troubled look, and he finally said to me, "Ike, I hate to abuse a good tool like this; I like to get out work in good season, but I think too much of a lathe to abuse it. Hear it groan, Ike." And he listened for imaginary signs of distress. "Why, I have always run a lathe on the second step of the cone for work about this size all my life, and I'd rather take a licking than crowd a lathe." I ventured to suggest that 12 feet was a little slow for cast iron, and that the belt didn't seem to be strained any too tight; but Jack was ready for me. "Yes, they put a big belt on a 16-inch lathe and then want you to pull till the belt breaks, never thinking about the poor lathe; and as for measuring the surface speed of work, that's all bosh; if you have the belt on the second cone, you're doing all you can." Jack may be a little cranky on the "second cone" business, but I've seen lots of men who always run the belt on a certain cone for cast iron, another for steel, and still another for brass, regardless of the size of the piece; the only change being when a large piece occasionally chattered or the boss came along when he had a little piece in the lathe that was barely turning, and invited him to get a move on. Of course, we can't always follow exactly the speeds laid down as best by experts, but we ought to get over the idea that the "second cone" is all right for cast iron. A very good rule was given to me by a well known shopman—something as follows: Run your work as fast as the tool will stand, and take as heavy a cut as the belt will pull comfortably. Of course this wants to be used with two or three grains of horse sense, as the size of the piece and its liability to spring are always to be considered, which is another proof that plain, bald-headed rules are apt to lead one astray unless he knows enough about the subject to use common sense in its application. In all branches of mechanics good judgment is really the main feature to be considered. But there is a limit to the speed of tools as well as other things, and it seems to have been reached in the planer line. Not the actual cutting speed, that often drags along at a snail's pace and then tries to make up lost time by jerking the platten back at seven times the forward speed. It looks well on paper and is a good talking point, but if the shop around the corner is a good sample, I'll take a little faster forward speed and drop off on the return; the one there slams back like a battering ram, and is laid up for repairs about half the

time. It's much the same here as in lathe work; some men get to feeling too deep an interest in the tool and imagine it won't stand a heavy cut, but it's the foreman's place to offset this compassion by a little moral persuasion. Planer speed is too often 10 and 12 feet a minute, when it could just as well be 18 to 24 feet in many cases, and I know of a few cases on long wrought iron work where 30 feet has been reached in regular work. Some planers won't stand this, and if you're burdened with the weak-kneed kind you must do the best possible; but speed them up all you can with safety and then watch for the smile on the "old man's" face when the work begins to roll out faster; perhaps the smile may indicate a dollar a week on your wages, if he's that that kind of a smiler.

It seems to be a prevailing idea, among some mechanics at least, that the man with the dirtiest overalls, with grease up to his elbows, and his nose, ears, etc., liberally blackened till he looks like a powder monkey, is the best mechanic—"ain't no dude machinist 'bout him; he just dives in and does the work; not 'fraid of a little dirt." There are a few men who go to the other extreme, and wear plug hats, frock coats and other clothes to match, changing all these before commencing work; these men are the dudes, probably; but though such things wouldn't fit on a fellow with the euphonius name of Podunk, I'll choose them before the others every time, other things being equal. No one ever accused me of being dudish; first place I'm too lazy; next, can't afford it; but if more of the machinists would take the trouble to change more of their clothes night and morning, they'd feel better, work easier and look better into the bargain. My plan is this: I keep old shoes at the shop—not noted for their beauty, but for good stout soles, and overalls and jumper to match. We have closets for clothes, and I peel down to the underclothes, put on the jumper, overalls, shoes and cap, and I'm ready for work. You feel much freer than with a whole wad of clothes on, and overalls over pants are a delusion and a snare. They don't keep the pants clean, for the oil will get through occasionally, and they give a man the spring fever about this time of year the worst of anything I know. It pays to dress cool and comfortable.

Then don't go home without washing up. Your wife may not fire you out, but it's asking a good deal of a woman to welcome a fellow who hasn't washed up, and who looks as though he had been used to swab out a chimney. You know very well you wouldn't have dared call on her in such a condition before she tempted fate and fortune by agreeing to wear your name, etc., etc.; so it don't seem hardly fair to go home now looking like a tramp and leaving your finger-mark and your foot-mark wherever you go. Soap is cheap, whether it floats or not, and you'll look better if you don't feel better, by using plenty of it before you leave the shop.

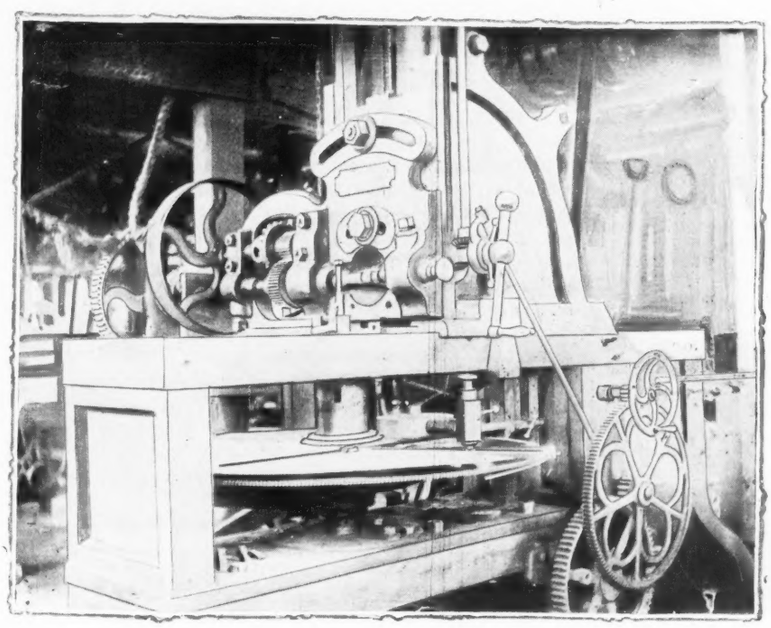


FIG. 1.—OLD GEAR CUTTER, 1841, SILVER, GAY & CO.

TWO OLD GEAR CUTTERS.

Gear cutting is always interesting, and though we usually think of nothing but cast teeth when speaking of old gears, this is not necessarily the case. In the shops of the Silver & Gay Co., North Chelmsford, Mass., which have been mentioned before, the writer found two old gear cutters, which are interesting in many ways.

The first one shown bears the date of 1841 on its name-plate,

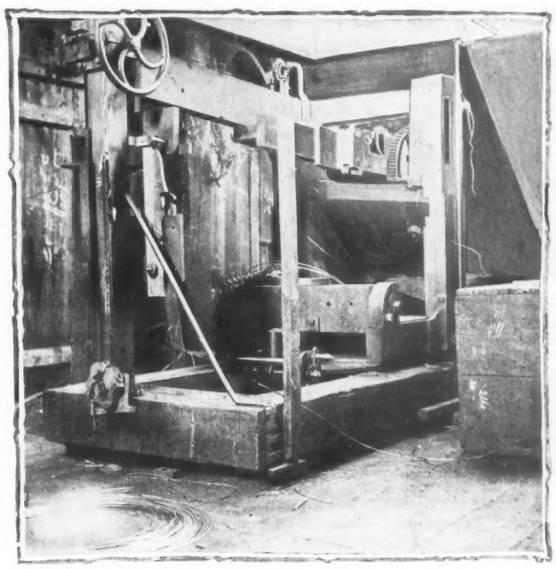


FIG. 2.—BEVEL GEAR PLANER, 1855.

but the records show that one was sold to the Stark Mills on July 10th, 1839, so they must have existed earlier than this, but probably in a less complete form.

As will be seen from the illustration, it is practically a universal machine, the head being capable of tipping back for bevel gears, and the large index plate below gives a wide range of divisions for numbers of teeth. A close study of this is interesting to any machinist who handles gear cutters.

Although this machine could not bevel gears, these mechanics (who had, I think, exceptionally good ideas for that time and place, as shown by the tools built and methods employed) saw the advantages of a planed tooth for these gears, and in the early '50's constructed the machine shown in Fig. 2, which I found in one corner of the attic. As will be seen, it was framed of heavy timber, although the wearing portions were of iron. The horizontal timber with the slotted arc in the end of the trunnion plate, held the wheel to be planed, the arc allowing any tilting that might be necessary for the wheel in hand. The tool-block shown just ahead of the gear in upper right-hand corner, moves back and forth on the iron way or beam, while the beam was guided at its outer end, the former being shown beneath the hand-wheel at the left. This allowed the use of a large former, with good bearing surface, and diminished instead of multiplied the errors it might contain. The tool-block was of the reversible type, which was so common in the earlier days, but which have been entirely abandoned, and with good reason in most cases. In these blocks the tool made a half revolution at each end of the stroke and presented its cutting surface in both directions, consequently cutting on both the forward and back stroke. There is a framed certificate in their office from the Middlesex Mechanics' Association, bearing date of 1857, awarding a gold medal to Gay, Silver & Co. (the old name of the firm) for this Bevel Gear Planer.

* * *

DON'T blame the other fellow for all the trouble.

GEAR-OLOGY.

SOME PRACTICAL FORMS OF GEAR TEETH.

F. W. CLOUGH.

It has been found that the science of forming gear teeth to run well together is not rigidly tied up to any one system exclusively, of that manner or system of the formation of teeth, provided that some essential principles be regarded in outlining.

Fig. 1 is a sample of the well known epicycloidal tooth—15 teeth with rack—whose forms are generated by a 7.5 inch describing circle for 1 to the inch pitch diameter. This form of teeth

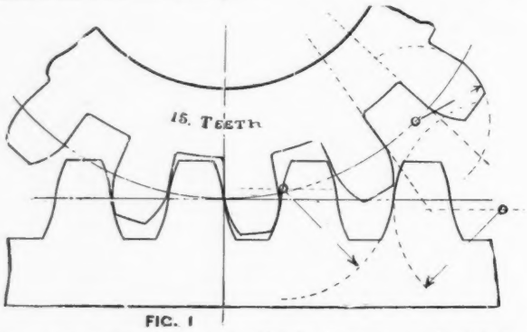


FIG. 1

has been claimed by some to be the best system of teeth to use. The writer has seen some very fine running wheels of this kind of teeth; also some not so fine; very likely some of the wrongness of the more noisy wheels was due to the men who cut and mounted them.

Fig. 2 illustrates what we may call a cycloidal tooth—a gear wheel of 15 teeth in mesh, with a rack. The origin of the form of these teeth is obtained by the rolling of a proper sized describing circle on the pitch line of rack, for rack teeth, and on chord lines (tooth to tooth) for wheels. The laying out of these teeth is an easy task on drawing board; in this case the radius of face

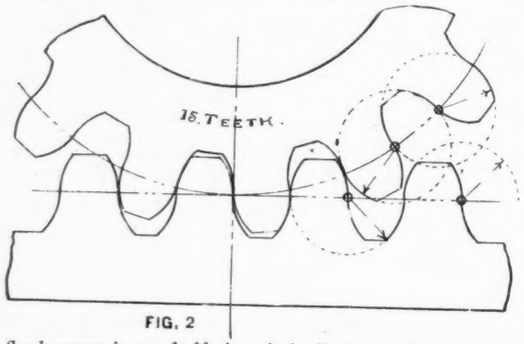


FIG. 2

and flank curve is one-half the pitch distance; dotted lines show tooth outline. These teeth run very smoothly when constructed correctly. The writer once had a pair mounted on a block run by a groove pulley, 6 pitch, 12 teeth each, which were practically noiseless at an ordinary speed and made very little noise, except a mild gear solo at 3,000 revolutions per minute.

Fig. 3 illustrates a rack and 12 toothed wheel of a modified radial flank. The flanks of 12 teeth are exactly radial, while wheels of more teeth vary from exact radial lines proportionate

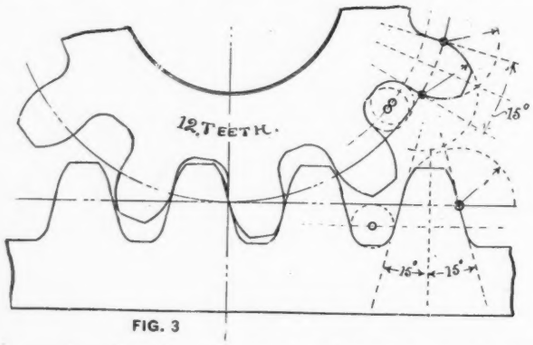


FIG. 3

to the number of teeth on wheels, and when we come to outline a rack tooth the flank lines are 15 degrees out from radial line. A large sized fillet is used at the base of teeth, which greatly strengthens them.

In Fig. 4 we show a rack and wheel of 15 teeth of the well known and much used involute system. An involute line is part of a scroll line. The rack teeth are formed by straight line face and flank at 14½ degrees each to a vertical line (or 29 degrees in all). The principle involved in forming these teeth is, that as the size of wheels increase, having an increased number of teeth,

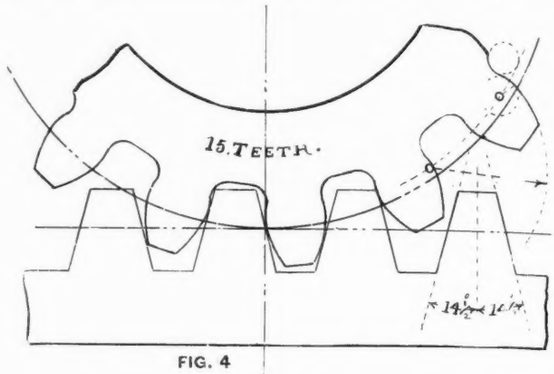


FIG. 4

the radius forming curve of teeth also increases until the rack is formed by a curve whose radius is infinite. This kind of tooth wears well in hard service, but is not always a quiet running wheel in comparison to some other forms of teeth.

Fig. 5 illustates an improved (by the writer) involute tooth 15 toothed wheel and a rack in gear. The method of forming this tooth outline is somewhat different from that of the ordinary involute, but the improved form obviates some difficulties found in that system. The rack teeth have curved face and flank made

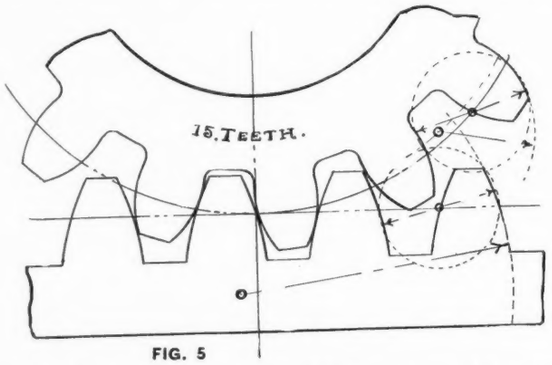


FIG. 5

by one radius and curve. When rightly constructed they have some manifest advantages over an ordinary involute tooth.

Fig. 6 shows the two extremes of the uniform tooth—a wheel having 15 teeth with a rack. By uniform teeth we mean this: that the teeth of varying sized wheels of the same pitch are of the same size and curvature. Observe that the teeth of rack are exactly like those on wheel; and in practice all wheels occurring within these two extremes have also the same identical (in size and shape) tooth. This kind of teeth have been found to run

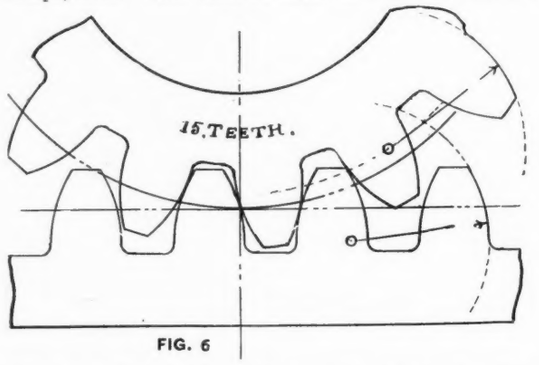


FIG. 6

well, wear well, and to possess features of advantage over some others having a higher name.

These are but samples of a variety in forming outline of teeth; each is a distinct system of itself, and embrace in each case a train of interchangeable wheels between the two extremes.

One or two very essential items concerning any pair of wheels whose teeth may be of any good tooth system; they must be cut

true; must be mounted and run true; well supported in bearings; and must run at a uniform speed.

* * *

ENLARGING THE SHOP.

FAYETTE FRANKWAY.

More than one machinist has come to downright grief through premature indulgence in a craze for enlarging his shop. Every one who starts in the machine business has enlargement in view from the beginning. It makes no difference whether the shop covers four acres of space or whether it is only 12 × 12 feet. Enlargement is the ever-present nightmare; the something that haunts dreams.

Nothing can be said against the intention towards enlargement. There ought to be such ambition, but there ought to be the firm determination to *wait till the time for enlargement comes.*

With the big shop—stock company—enlargement is simple enough. If it comes about that it was not needed, dividends are a trifle less. I am not writing for these companies. They know their business better than I do. But with the mechanic with his few dollars saving, all invested in his little shop, the case is different—quite different. He is struggling along for a foothold in the mechanical world. A little in debt, but gradually and surely working out, all in his little shop. Orders come in rather brisk for a bit, and the little shop is too small. Then comes the enlargement. Directly business drops back to its regular standing. He must pay interest for the cost of enlargement; his expenses are more in every way, and then disaster comes. It is a case of premature enlargement.

I have in my mind just at this writing a machinist who had a modest shop in which he was doing very well—getting a good living and saving money. He had, besides general work, one specialty—his own invention, of which he was naturally enough a little proud. Well-meaning friends persuaded him that immediate enlargement of his facilities and pushing the sales of his invention were essential. He branched out, as they say, branched out beyond his means, and mark the result: To-day he is running a little engine, getting, I suppose, about a dollar and a half a day. This is not "written for the occasion;" it is the recital of an actual fact, that can be matched a hundred times over. Had the party referred to waited for two or three years he would have been successful, beyond much doubt.

Mind, I am not writing against enlargement. Like everyone interested in what comes out of the machine shop, I like to read of enlargement. I am writing only against premature enlargement, that has ruined a good many aspiring machinists. It is better, so it seems to me, to let the shop crowd you for a little time than to pay interest and taxes and spend money otherwise in a vain attempt to crowd a big shop, that business is not ready for.

* * *

HOW TO SELECT A SLIDE RULE.

WILLIAM COX.

Next in importance to *knowing how to use the slide rule* is *knowing how to select one*, as the reliability of the work done with it depends largely upon the accuracy of its graduations, just as a table of 4 place logarithms gives results which are only approximate, and for greater accuracy recourse must be had to those of 7 figures.

When, therefore, about to purchase a slide rule, the first point to be decided is what sort of an instrument to buy, so that the work intended to be done with it may be performed with the greatest amount of convenience, facility and reliability. I say without hesitation that, for ordinary use, preference should be given to that one having the particular combination of scales known as the "Mannheim," the invention of an officer of artillery of that name. In this slide rule, which is usually 10 inches long, the two top scales A and B are alike, being double ones, whilst the two bottom scales C and D are single ones, also alike, as has already been described in these columns. In the older slide rules the three scales A, B and C are double ones, whilst the bottom scale D alone is a single one, thus rendering impossible the use of the two lower scales for solving problems in proportion, etc. A brass runner should always be provided, as it facilitates considerably reading and setting and the working out of extensive calculations without reading off intermediate results, thus securing greater accuracy in the final one.

The next point to be considered is the question of material. Some slide rules are made of boxwood throughout, some of boxwood coated with celluloid, whilst others, which are the clearest and most distinct that I know of, are of mahogany coated with celluloid, the graduations being dark blue on a clean creamy white ground. There are probably more of these latter used in this country than any other kind. The lines being clear and well defined, the eyes are not affected by long use of the instrument, and the results may for the same reason be probably more accurate than those obtained with simple boxwood rules. Fortunately too for the purchaser, these slide rules are less expensive than the boxwood ones.

Having settled these different points, and obtained a slide rule, the most important work of all remains to be done, that is, to test it to see if it is accurately divided. To do this, begin by making primary line 3 of scale C of the slide coincide with primary line 3 of scale D of the rule, then note if all other lines of the rule and slide coincide, especially the right and left indices. If they do not, exchange the instrument *at once* for another one which will stand this test. If the lines coincide, proceed further as follows: Draw the slide out to the right so that its left index coincides with primary line 2 of scale D of the rule, and note if all the other primary lines coincide, also if the left index of the slide coincides with primary line 4 of scale A. Now draw the slide still further out and set it so that its left index coincides with primary line 3 of scale D, and examine to see if the same index coincides with primary line 9 of scale A. The following coincidences should also be found:

Scale A.	18	27	36	45	54	63	72	81
Scale B.	2	3	4	5	6	7	8	9

also the following:

Scale C.	11	15	18	2	25	3
Scale D.	33	45	54	6	75	9

If the instrument successfully stands these tests, take the slide right out and re-insert it, but turned about so that the top scale of the slide lies along the bottom scale of the rule, then make all indices coincide, and see if the following coincidences also exist:

Scale A.	4	16	25
Scale C.	5	25	2

also,

Scale B.	25	16	4
Scale D.	2	25	5

then by means of the runner observe if the following coincidences exist:

Scale C.	8	5	4	25	2	125
Scale D.	125	2	25	4	5	8

If the results of these various tests are satisfactory, the rule may be considered trustworthy.

One more point deserves a passing mention. The slide may be found to work stiffly. This may not really be a defect but a consequence of the weather, as a slide rule kept on one's desk and used daily is as sensitive a hygrometer as any one may desire to possess. Do not, however, on this account immediately commence paring away the inner edges to ease it, but wait patiently for a spell of dry weather, then if the stiffness continues, very carefully with a little fine emery cloth or sandpaper rub down evenly the inner contact edges of the celluloid, taking care that the pruning process be applied equally to every part of the slide and rule, otherwise the settings of the slide will be jerky and accuracy will not be easily attained. Care must also be exercised not to round the edges of the celluloid, but to leave them sharp and well-defined, so as to preserve the close contact of the slide and the rule.

All these points being duly attended to, make your slide rule your constant companion, as you would a dictionary if learning a foreign language, and you will in a short time be surprised at the hours of pleasure that may be derived from its use.

* * *

ONE of the largest steel houses of Boston have established quite a business in cutting off steel in any length desired. This is very convenient for the customer and profitable to the other parties. The customer only buys just what he needs and can well afford to pay a price high enough to cover cutting and waste, in preference to buying a whole bar that may never be used. The business has grown until it keeps more than one cutting-off machine busy to supply the demand. There are probably other lines where little conveniences of this kind would be appreciated and profitable.

BRAINS AND ECONOMY.

W. De Sanno.

If there is one thing more than another that will give a fellow "that tired feeling," it is the periodical cry to economize. When properly applied, economy is only another name for brains. A man holding a subordinate position, wishes to make some changes in his department, with a view to facilitating his work and increasing the output. The proposed changes are submitted to his superior; what is the result? The brainy foreman is met with the old song, "No, it costs too much now to do the work; the company cannot stand these changes." Yes, it does *cost too much* now. Brains wishes to reduce the cost, but the damphool in authority prefers to continue the present costly way of doing the work; perhaps it is because he cannot think of any better way of doing it.

The writer once worked for a railroad company; a new man was sent to take charge of the car department, and he was a hustler from awayback. The first thing the new man did was to get his longitude and latitude, and then sail in. He first cleaned up the shop and grounds, and if there was not enough refuse to fill up the low places, he made a requisition for ballast by the car load, and he got it. He next assembled and assorted his scrap; built casting and other bins under cover; assorted and located every piece of wood or iron used in car work, and in such a way that there was no hunting for something when wanted in a hurry.

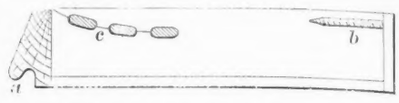
Next, instead of using an old hand truck to transfer material to or from the blacksmith shop, or about the yard, he hunted up a lot of old rails, and built a narrow gauge system, then got a lot of hand-car wheels, and built push-cars, so that one man could do as much work in his transportation department as six men could do under the old order of things. He was level-headed enough to see that there was room for improvement, and to the advantage of the company. Instead of asking the question, will the company stand it? he went to work and made the changes. Yes, it cost some money, but it paid well. Did the company kick? Yes, by giving him a better job. Railroad companies will wink at improvements, if *they* make money by the move.

Consistent economy, prudently enforced, is all right. Useless waste is all wrong. In nine times out of ten, retrenchment is the result of a lack of brains in the management of a concern. Close shrewd management is not an impossibility when the manager or general foreman of a machine shop has a practical knowledge of the business. The running expenses of a machine shop are varied and many, and require close watching. I have seen a man running a drill press use a quart oil can with the spout broken off, pouring oil on a $\frac{3}{16}$ drill. It is not uncommon to see a man use oil enough in tapping a nut to do a dozen, and there is no one to say don't. The same case applies in the breakage of of taps and reamers. Just so long as a man can go the tool room and get new ones to replace those he broke, without any questions being asked, so long will the destruction go on. Instead of kicking these destroyers out of the shop, they are retained at a loss. As the slop pail of a poor family, so is the scrap pile of a machine shop, both indications of good or bad management.

* * *

DRAWER FOR TRACINGS.

Of the many devices for keeping tracings in their proper shape —that is, flat—the accompanying sketch seems to fill the bill as well as anything we have seen. The persuaders *b* and *c* are apparently able to do their work in good shape and are certainly cheap. The back coaxer is simply a strip of light board across the back of the drawer, projecting perhaps six inches toward the front and a little below the top of drawer. The front attachment, which seems to be



a cross between a life-raft and a spring bed, is made of three wooden strips of about ½×1½ inches, fastened by three or more strips of heavy tape, upholsterers' tape, I should judge. These are readily laid out over the edge of the drawer when removing or replacing tracings; but when in place as shown they prevent the edges being curled by projecting above the drawer.

The handle *a* runs the whole length of the drawer, in fact forming its front, the stock being got out of the section shown, the lip forming a good handle for the drawer. This device is used at the Pratt & Whitney Co.'s shop, Hartford, Conn., and in other places.

* * *

PRACTICAL TALKS ON MECHANICAL DRAWING.—(6).

Louis Rouillion.

It is desirable that the student should, if possible, procure objects somewhat similar to those shown in the following plates. Where this is impracticable, the plates may be used as sketches. When the drawing is to be made from the object, a pencil sketch is first made. Dimensions are taken with foot-rule and calipers. The sketch should be free-hand and carefully executed. All dimensions should be shown. The greatest care should be exercised in the placing of dimensions. No general rule can be laid down, as the proper dimensioning of a drawing is a matter of experience. The draftsman should be familiar with machine shop practice, and put such dimensions on his drawings as best serve the purpose of the workman. A fair test of whether a sketch is correctly drawn or not, is to consider if the object could be made from the sketch direct.

To lay out a sheet the first thing to consider is the scale to which the drawing is to be made. Full size drawings are preferable, but where large objects are to be shown the drawings are reduced to a smaller scale. The boxwood scale used by draftsmen is graduated to various scales, as ¼, ⅜, ½, etc. In drawing to one-half scale each line is made but one-half of the given dimension. If a drawing is required to be made to an odd scale, a special drawing scale may be made by laying off along the edge of a slip of paper a distance equal to the reduced foot and dividing this distance into twelfths and fractions of a twelfth. The reduced foot is then used as a full foot.

Having decided upon the scale to which the drawing is to be made, the center lines are next located, and the drawing built up about them.

SHEET XX.

SEVEN-INCH PULLEY.

In Sheet IV. we learned that "when an object to be sectioned is the same on both sides of its center-line, only one side is sectioned, while the other is drawn in full." In Fig. 27 we find an application of this rule. The pulley is symmetrical about the center of the shaft, therefore in sectioning, the top half alone is shown. The lower half of the pulley is here shown in outline,

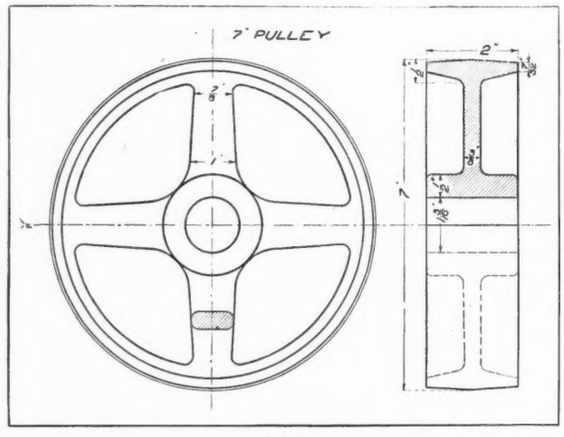


FIG. 27.

though the drawing would be quite as serviceable without the hidden parts. As many dimensions as possible should be given on one view. The same dimension should not be repeated. Where a dimension is given on a sectional surface, the section lines should not cross the figures. The figures should be at least one-eighth inch in height and be strong and distinct. Do not crowd the figures. Where there is not room for both the figures and arrow-heads between the lines, the arrow-heads may be placed outside the lines as shown at the upper right-hand corner of Fig. 27. See that all unfinished corners of castings are rounded.

SHEET XXI.

CONE FULLEY.

A part of the shaft is here shown to bring out the rule that shafts are not sectioned. Spindles, studs, screws, bolts and nuts are also included in this rule.

The upper half of the pulley is shown in outline, thereby doing away with the hidden lines showing the interior construction. This necessitates a method of giving inside diameters when only

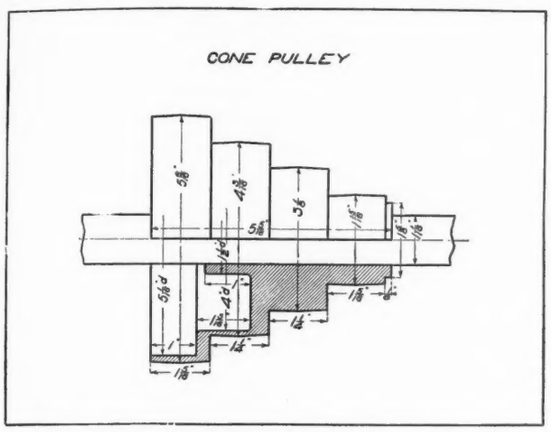


FIG. 28.

one side is drawn. A method of doing this is shown in the case of the inside diameter of the largest step. The dimension is written, $5\frac{1}{16}$" d, the arrow-head rests against the sectioned side and the dimension line is extended indefinitely in the direction of the other side. The letter d signifies diameter.

Only one view of the pulley is shown. This is in obedience to the rule that "where an end view shows only circles this view should be omitted.

SHEET XXII.

MONKEY WRENCH.

This sheet shows one method of putting in the pitch of a thread. The pitch is designated as "Pitch-11," or may be abbreviated to read simply "P-11." If the thread is a left-handed one it is so noted on the drawing, otherwise it is understood to be right-handed. A single thread is understood unless otherwise noted

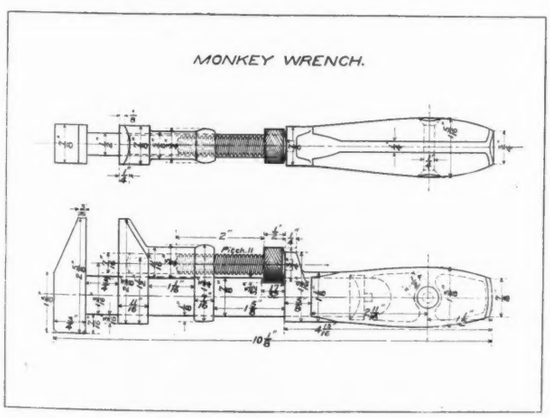


FIG. 29.

The interior construction of the handle is here suggested but not dimensioned. A scheme for putting in small dimensions is shown in the case of the topmost dimension of the sheet. Two arrow-heads embrace the part to be dimensioned and the shaft of one of the arrows serves as the division line of the fraction.

SHEET XXIII.

GLOBE VALVE.

Only general dimensions are here shown, to avoid unintelligible crowding in so small a reduction. Only one view is necessary, although two are here shown. The diameter of the globe may be given in an accompanying note. It will be noticed that the spin-

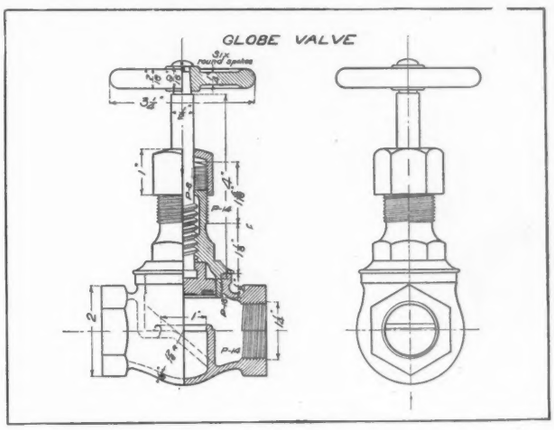


FIG. 30.

dle is not sectioned; observing the rule laid down in Sheet XXI. As the valve-seat is not the same on both sides of the center line the left-hand side is here shown by hidden lines. Another method of showing the construction of the valve-seat is to break away a piece of the wall of the globe and show the entire valve-seat in section.

SHEET XXIV.

PILLOW BLOCK.

Center-line all holes and give the distance between centers. An endeavor has been made to adopt a standard section-lining to represent different materials. A section-lining to represent bab-

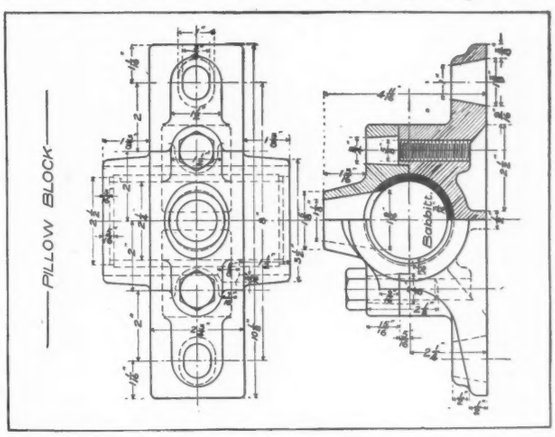


FIG. 31.

bitt metal is here shown. It consists of lines drawn at 30 or 60 degrees in both directions. The purpose of such section-llning is generally more easily and satisfactorily obtained by giving the name of the material in an accompanying note.

EXERCISES.

EXERCISES 20 TO 24.

Make working drawings of simple objects. The following list may be suggestive of suitable material: Various kinds of pulleys, clamps, wrenches, valves, simple vises, faucets, anvils, shafting details, engine details, etc.

* * *

WM. H. BOOTH, member American Society Civil Engineers, formerly of New York, has resigned his appointment as managing engineer of the Legrand & Sutcliff Artesian Well Co., and has taken offices at Picadilly Mansions, No. 17 Shaftesbury avenue, London, W., where he will practice in steam engineering, water supply and electrical transmission of power, paying special attention to artesian work, questions of hydrogeology and electrical transmission, and the introduction of good American patents to manufacturers and financiers in Great Britain. He would be glad of all American catalogues and is desirous of taking up the representation of good American houses, his office being in a central location.

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WE solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense.

ALL copy must reach us by the 10th of the month preceding publication.

Special Offers for May.

TO ANYONE sending us three NEW subscriptions to MACHINERY at $1.00 each, we will send a 10,000 mile cyclometer, which is correct; some cyclometers are not.

TO ANYONE sending us two NEW subscriptions to MACHINERY at $1.00 each, we will send "Shop Kinks," by R. Grimshaw, a 400 page book which sells for $2.50. You want it

TO ANYONE sending us two NEW subscriptions to MACHINERY at $1.00 each, we will send free a pair of 5-inch adjustable calipers, inside or outside, which sell for $1.00 in any store. A pair of 8-inch ones for three NEW subscriptions at $1.00 each.

FOR ANYONE sending us five NEW subscriptions to MACHINERY at $1.00 each, we will haye a thorough preliminary examination made by a well-known attorney to ascertain the patentability of any device. The regular charge for this is $5.

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THIS PAPER HAS THE LARGEST CIRCULATION OF ANY PUBLICATION IN THE MACHINERY TRADE

MAY, 1896.

WE have arranged with Mr. George Richmond, a well known authority on oil and gas engines, to write a series of practical articles on these important types of motors, to begin in the June issue. The growing demand for these engines for small and medium powers, as well as the marked tendency to use them in larger units, makes this a timely and valuable series.

* * *

DAILY vs. TECHNICAL PAPERS.

Any one who has taken the trouble to dissect the news matter contained in the average daily paper, or to compare the narrative with the actual facts, if he be familiar with them, cannot help coming to the conclusion either that a premium on exaggeration is offered to most writers in the daily press, or that they are allowed to draw on their imaginations at will so as to fill all the space the editor will place to their credit. No reasonable person expects to find in a daily paper the same accuracy which is imposed on the technical press; but there ought to be some limit to the misstatements contained in most of the "great" newspapers whose proprietors would be highly offended if the term "sensational" were applied to them. The public taste has become so poisoned by this kind of journalism that the majority of readers require their news "dressed up" in such a fashion as to appeal to their baser natures; and but one daily paper in the great city of New York—the *Evening Post*—to its honor be it said, presents the news of the day in plain, well written language, containing as nearly as possible the facts and nothing else.

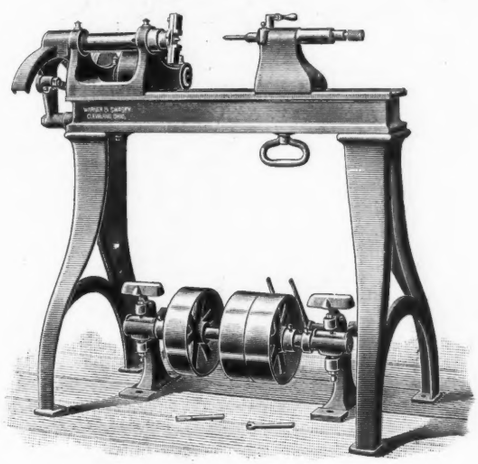
What proportion of the readers of a technical paper would permit statements concerning their profession to be presented to them clothed in the maliciously incorrect verbiage which they accept without a murmur in their dailies? What value would they place on its statements? Every editor of a technical paper knows that the simple misplacement of a decimal point, or a typographical error no greater than that which changes "improved" to "imported," as happened in this paper last month, is immediately called to his attention. Surely the progress of sensational journalism has reached a point were a reaction is called for in favor of honesty and common sense.

* * *

WHERE THE LINE MUST BE DRAWN.

The customary method of establishing a trade paper has been to obtain all the advertising possible at first and then make an effort to get readers. When MACHINERY was established this process was reversed; the readers were first obtained and then the advertising followed naturally. The policy of the paper has always been to consider its readers before its advertisers; and we believe that every advertiser, when he carefully considers the question, will agree with us that this policy is best, for the readers are absolutely essential to the profit of the advertiser; without them no advertisement can pay. In pursuing this policy we do not intend to present to our readers as new, any machine or appliance which has been previously illustrated and for any length of time upon the market. We appreciate the fact that a manufacturer spends money for an advertisement in MACHINERY in order to get returns; and within certain legitimate and necessary limits we endeavor to do everything possible to make his advertisement pay him; but we draw the line distinctly at inserting in our reading matter anything not conforming to the above restrictions. The Davis & Egan Company, who, with their predecessors, have been advertisers in this paper since the sixth issue, and with whom our relations have always been of the pleasantest character, are well aware of this policy for it was carefully explained to them at the time the contract was made; but they sent us for publication in the April issue an engraving which not only represented an old machine that had been on the market for some years, but which was a fac simile of an illustration that appeared in Warner & Swasey's cata-

logue of 1893, and which the Davis & Egan Company say was made from the latter illustration "*previous* to getting up this (their own) machine." It may be said that we should have known this tool was made by Warner & Swasey and have refused to illustrate it in our columns; but it is an impossibility for any editor to carry in his memory all the different varieties of tools and appliances that are put on the market from time to time, many of the new ones containing only some small improvement which justifies their appearance; and as no editor can safely assert that a tool is not new which is said by a reputable manufacturer to be new, without devoting considerable time—more time than most editors have at their disposal—to a search through catalogues and circulars bearing on that particular line; he necessarily relies to a certain extent on the good faith of the manufacturer who sends illustrations to appear in the paper. Having, through accident or design on the part of others, published an illustration which not only did not conform to our conditions, but which was really the property of another manufacturer, it became our duty to make such amends to the rightful owners as were possible, and immediately on receipt of Warner & Swasey's letter we wrote the Davis & Egan Company calling their attention to the assertions contained therein, which we found on examination to be true, and stating that unless



WARNER & SWASEY COCK GRINDER.

they could furnish us with some good reason to the contrary we should be obliged to publish the correspondence and engravings in the next issue of MACHINERY. This it now becomes our unpleasant duty to do.

The fact that the Davis & Egan Company are advertisers in MACHINERY while Warner & Swasey are not, and may never be, makes this duty imperative; for we will not allow it to be said that any manufacturer can buy a large enough space in MACHINERY to control its reading columns. It is not in our province to pass on the moral question involved, but we shall in every case do our best to discourage such practices when we come in contact with them—without fear or favor.

I.

OFFICE OF

THE DAVIS & EGAN MACHINE TOOL CO.,

CINCINNATI, March 10, 1896.

THE INDUSTRIAL PRESS, NEW YORK:

GENTLEMEN:—We enclose you herewith description of our new Cock Grinder, which we would ask you to illustrate in your next issue. This is a very convenient little tool and we feel that it would be of much interest to the brass trade. We enclose electrotype under another cover.

Thanking you for past favors, we are

Yours truly,

THE DAVIS & EGAN MACHINE TOOL CO.
G. C. MILLER.

II.

OFFICE OF

WARNER & SWASEY,

CLEVELAND, OHIO, U. S. A., April 11, 1896.

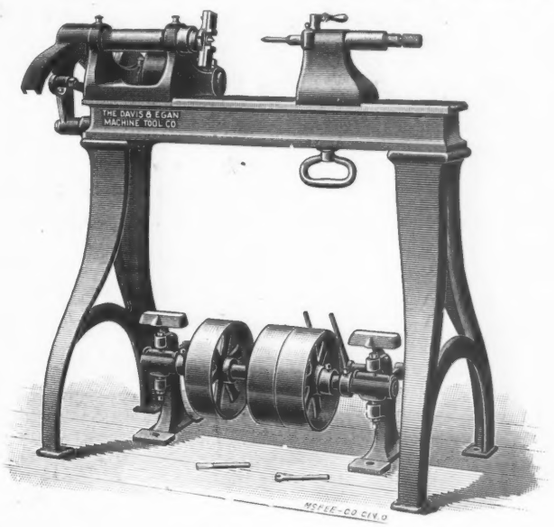
EDITORS MACHINERY, NEW YORK, N. Y.:

GENTLEMEN:—In the April issue of your valuable periodical we notice an example of a curious coincidence, illustrated by the two cuts which we append to this sheet. One of them is taken from our catalogue, which was published in 1893, representing a machine which we have been making for the past ten years, and the other we cut from the lower right-hand corner of page 225 of your April issue. The coincidence is not in the similarity of the two machines, but the fact that the wrenches on the floor, the drip cups of the hangers, the oil caps on top of the spindle bearings, the cracks in the floor, and even the shadows which the machine throws on the floor, are exactly alike. The only point of difference is manifest on the front side of the bed toward the left-hand, where the names on the two are evidently not alike. We have often had occasion to quote the old saying that "Imitation is the sincerest flattery," but that does not seem to apply in this case, for instead of imitation, one party seems to have appropriated the whole machine, "horse, foot and dragoons." This calls to our mind another familiar quotation, which implies that there is "honor among thieves;" but that does not apply in this case, for they have stolen every element shown in our cut, even to the shadows, and there seems to be no place left for honor.

We are glad to submit the two cuts for your inspection, and do not consider further comment necessary.

Yours respectfully,

WARNER & SWASEY.



DAVIS & EGAN COCK GRINDER.

III.

OFFICE OF

THE DAVIS & EGAN MACHINE TOOL CO.

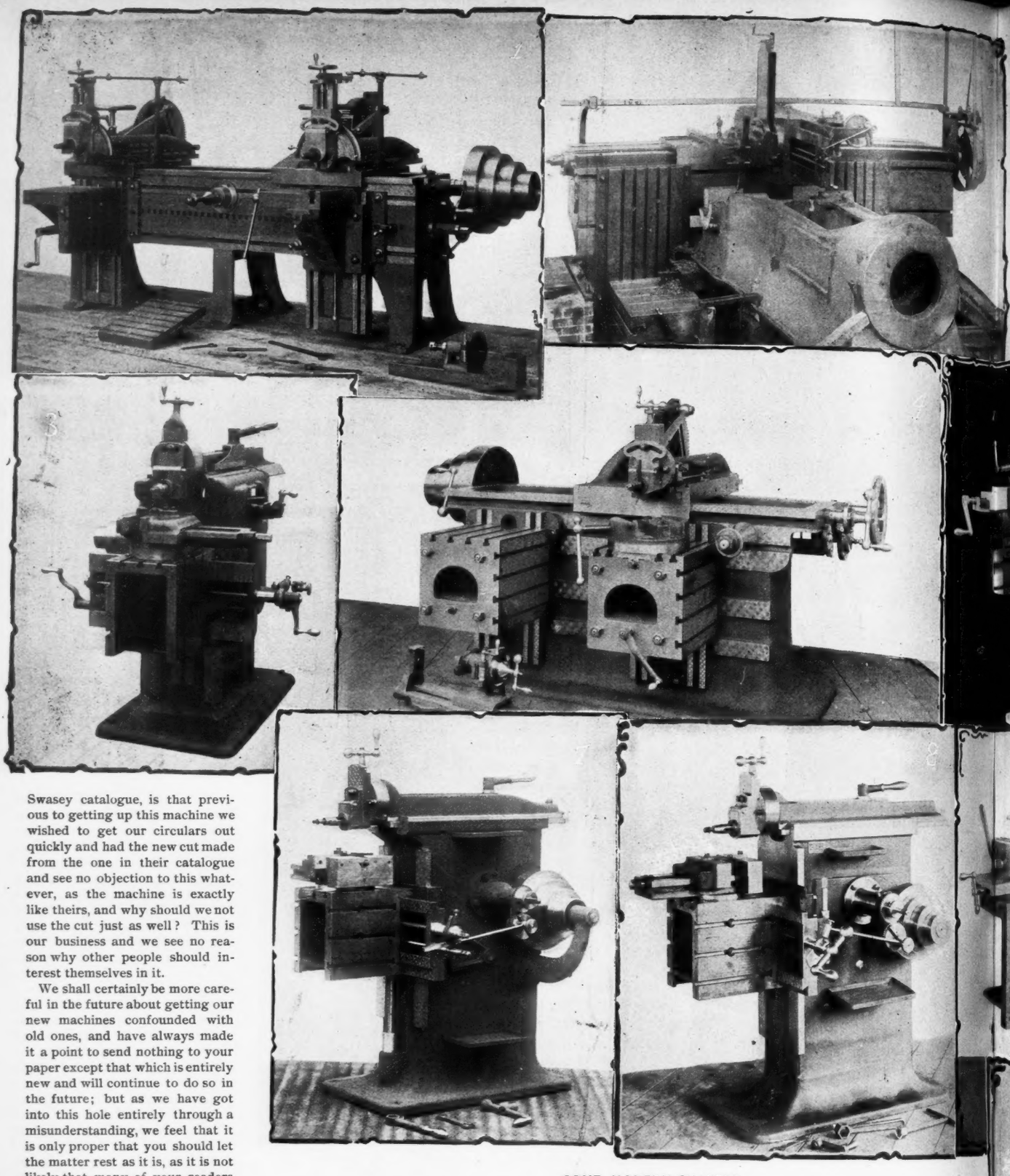
CINCINNATI, April 16th, 1896.

THE INDUSTRIAL PRESS, New York City.

GENTLEMEN:—We have your favor of the 13th enclosing copy of letter from Warner & Swasey and regret very much that the matter has come around in the shape it has. It was not our intention to illustrate this cock grinder in your paper. The writer left the city some weeks ago and issued instructions to our advertising man to illustrate in your paper our new double cock grinder, but in some manner he overlooked the matter of the new machine and forwarded to you cut of our single cock grinder, which is the same as the Warner & Swasey.

We enclose you herewith photograph of our new double cock grinder, which you can see at a glance is capable of doing double the amount of work of the old style machine, and is more simple in construction. However, as the old style cock grinder was illustrated in your paper, we see no reason to create any comment on the matter as you suggest, by publishing the entire correspondence of Warner & Swasey and running the two cuts. We certainly are opposed to such action on your part, and in case you do this we would not be inclined to give you the good word that we have always spoken for you, as the matter is purely a mistake on our part and the publication of this mistake would do us more harm than good.

We cannot see how in any way the illustration of this machine imposes on your paper, as we are making and selling this cock grinder, and it is just as much the Davis & Egan as it is the Warner & Swasey. The reason the cut is exactly the same as is used in the Warner &



SOME MODERN SHAPERS.

1.—Niles Tool Works, Hamilton, Ohio.
2.—Pedrick & Ayer Co., Philadelphia, Pa.
3.—Prentiss Tool & Supply Co., New York, N. Y.
4.—Fitchburg Machine Works, Fitchburg, Mass.
5.—Fox Machine Co., Grand Rapids, Mich.
6.—Flather & Co., Nashua, N. H.
7.—Davis & Egan Machine Tool Co., Cincinnati, Ohio.
8.—Springfield Machine Tool Co., Springfield, Ohio.
9.—Pratt & Whitney Co., Hartford, Conn.
10.—George D. Walcott & Co., Jackson, Mich.
11.—Hendey Machine Co., Torrington, Conn.
12.—Gould & Eberhardt, Newark, N. J.
13.—Newton Machine Tool Works, Philadelphia, Pa.

Swasey catalogue, is that previous to getting up this machine we wished to get our circulars out quickly and had the new cut made from the one in their catalogue and see no objection to this whatever, as the machine is exactly like theirs, and why should we not use the cut just as well? This is our business and we see no reason why other people should interest themselves in it.

We shall certainly be more careful in the future about getting our new machines confounded with old ones, and have always made it a point to send nothing to your paper except that which is entirely new and will continue to do so in the future; but as we have got into this hole entirely through a misunderstanding, we feel that it is only proper that you should let the matter rest as it is, as it is not likely that many of your readers have noticed that the machine is the same as Warner & Swasey. In fact, we doubt very much whether any other parties have commented upon it with the exception of the Warner & Swasey people, and they are only sore that we should enter upon the market with the same kind of machine as they are building.

Yours truly,

THE DAVIS & EGAN MACHINE TOOL CO.
B. B. Quillen, Secretary.

* * *

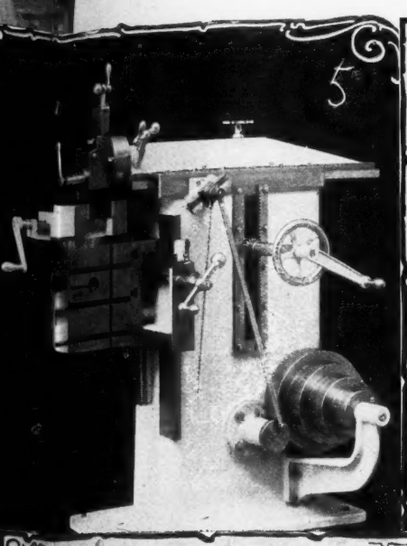
One of the annoying errors which sometimes creep into print made us refer to the latest catalog of the W. & S. Hydraulic Machinery Works, 204 East 43d street, New York, as containing their "imported" jacks, instead of "improved" jacks. This was rather exasperating, as they employ both men and materials of native origin and do not import anything. The error lies between the poor penmanship of the writer, the compositor and the proof-reader, and the feud hasn't been settled yet.

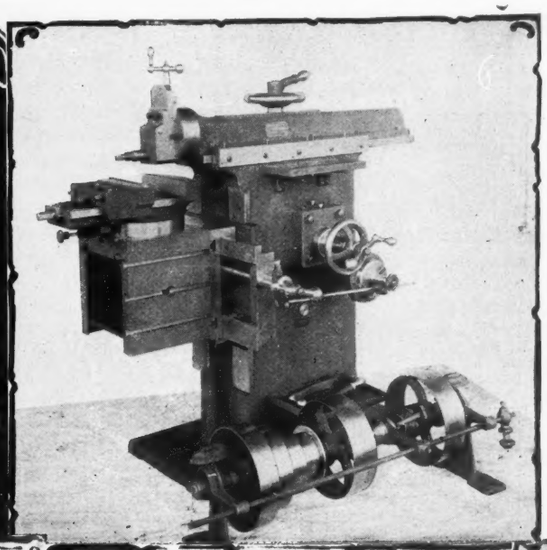
* * *

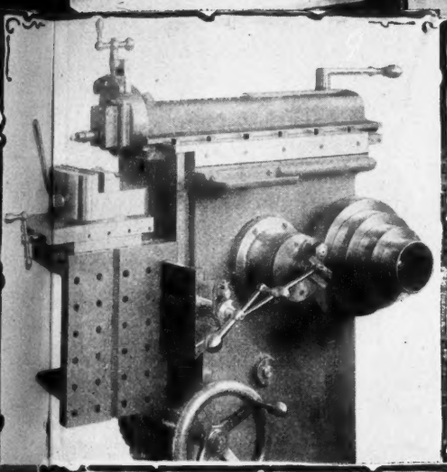
Twist Drill Clearance.—If the clearance of a twist drill is not perfect, the drill will not cut; the application of power to force it to cut will either crush or split.

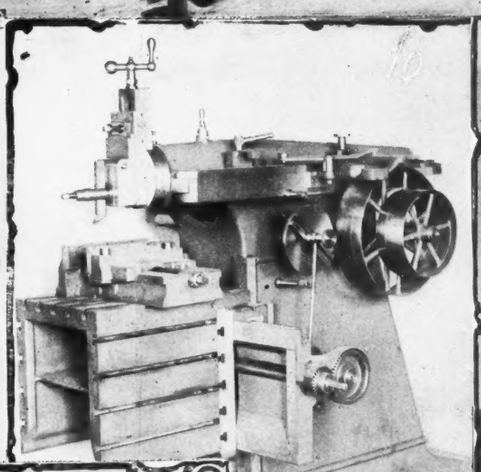
SOME MODERN SHAPERS.

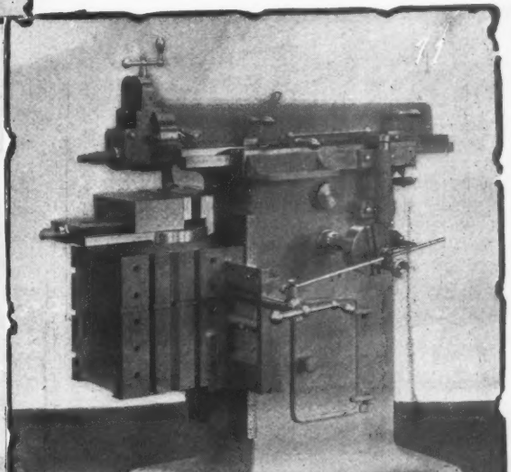
On this and the following pages are illustrated most of the leading shapers on the American market to-day; the general appearance being shown in the photographic reproductions below and a few details among the descriptive matter which follows. These are not as complete as might be desired, owing to our inability to secure the required information from the makers, and the amount of readng matter does not necessarily reflect the value of a machine as some of the best known machines have the least text for the very reason that they are well-known. One or two makers are bringing out new designs, and not wishing to show their older ones, yet not being ready with the new, preferred to be omitted from the collection. We believe much is to be gained by a careful study of existing designs in any line of machinery, for, as has been truly said, there is much information to be had from catalogs of leading tool builders, more at times than can be obtained in any other way, as they show the machines that are actually in successful operation. The descriptions follow in alphabetical order.

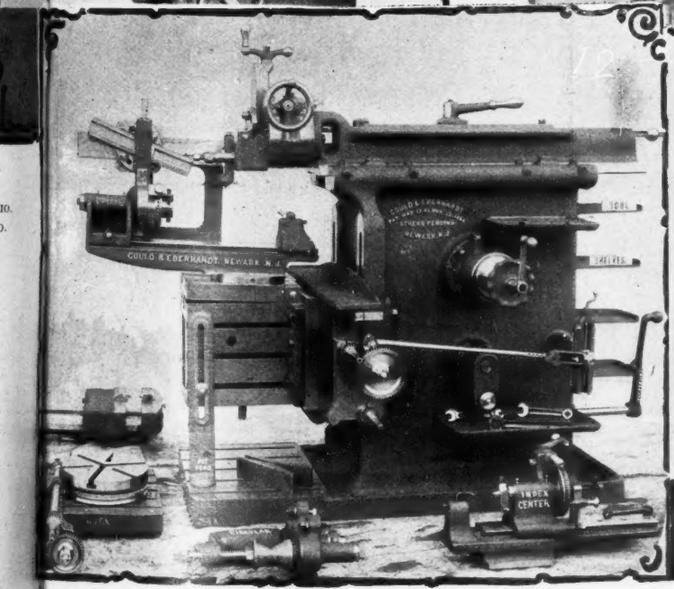


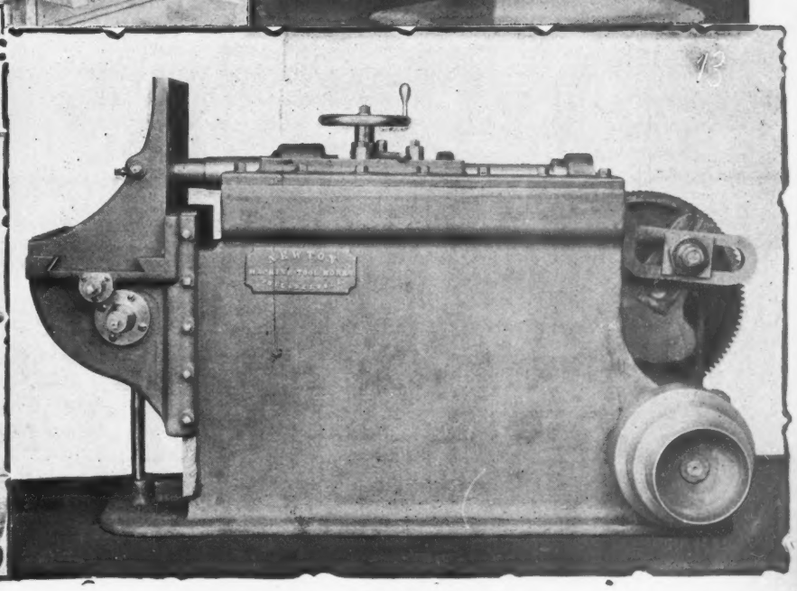












DAVIS & EGAN MACHINE TOOL CO., CINCINNATI, OHIO.

The accompanying cut shows the design and construction of this make of crank shaper.

The movement of the ram is of the vibrating arm type and, as is clearly shown on the drawings, the crank pin for regulating the stroke is adjusted by a screw and bevel gears from the outside of the machine while in motion. The top of the vibrating arm is made fork shaped, and double links, *a a*, connect it with the attaching shoe of the ram. This shoe, sliding on the under side of the ram, is operated by means of a pair of mitre gears *c c*, screw *b* and stem A, to change the relative position of the cutting tool to the table. This can also be done while the machine is running and the usual clamp arrangement *d* holds it firm to the ram.

The vibrating arm shaft is provided with a segment, indexed to show the length of the stroke. A novel self-adjusting feeding device is applied to the cross feed screw so as to avoid setting for the different positions of the table. The connecting rod *e* has at its front end a rack which has a reciprocating motion, meshing with pinion *h*, which is fixed to the rocking pawl carrier *f*, and so transmits motion to the ratchet wheel *g* fastened to the cross feed screw.

The double links before mentioned, provide an open space under the ram, through which long shafts can be passed for cutting keyways. The ram adjusts near the head, which is a convenience to the operator, as he need not move from the front of the machine to make his adjustments. The top part of column is carried forward several inches,

giving the ram an extra long bearing in the slides. Sufficient belt power is provided for heaviest cuts.

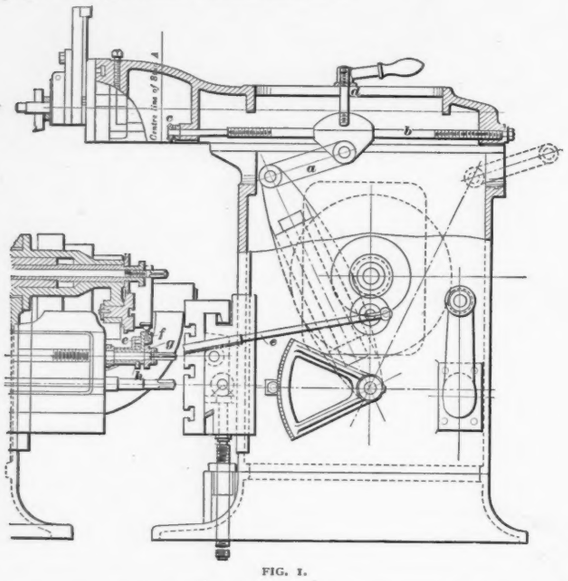


FIG. 1.

FITCHBURG MACHINE WORKS, FITCHBURG, MASS.

This machine has a head that travels on the bed, instead of having a traveling table, allowing a larger range of work. Table is clamped to bed, avoiding sag due to sliding fit. The one shown has an 18-inch stroke, which is obtained by a Whitworth quick-return crank, which planes to a line, with which most mechanics are familiar. The feed of swivelling head is obtained by device shown on side of ram and in detail in Fig. 2. The cranks C and F, connected by a rod, are fastened to side of ram, and the finger on F tripped by the stop G. This communicates the motion to C, and a pawl on the right of (and behind) this actuates a ratchet, shown behind the arm D in the small figure. The bevel gear A on other end of shaft meshes into the small gear on the right of shaft B, which in turn drives the other bevel gears shown and gives the feed to tool-block. As this swivels concentrically with the shaft B, it does not matter at what angle the head may be set, the feed is the same. The feed mechanism is shown at right hand of bed and does not differ materially from other devices for obtaining a similar feed. The desired stroke is obtained by varying the dis-

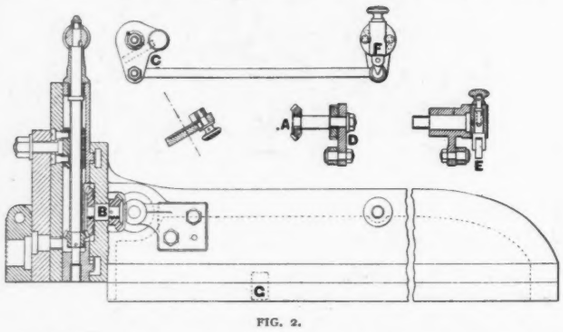


FIG. 2.

tance of the crank-pin from the center of disc, as is usual in crank shapers, and the *relative* position of the ram can be adjusted by usual slot and locking bolt.

The ram is 40 inches long and has a bearing of 29½×8½ inches. The saddle has a cross movement of 54 inches. The top of bed is 75 inches long and 20 inches wide. The head has a vertical movement of 5¾ inches, and is provided with power vertical and angular feed. The head is graduated so the tool can be set at any angle desired, and has a micrometer attachment on the feed screw reading to thousandths of an inch. It has two tables, each 16½×17 inches, forming angle irons 16½×16 inches. These tables have a vertical movement of 14 inches; greatest distance from bottom of ram to top of tables, 16 inches. A cone mandrel is provided with independent automatic circular feed. A hole through bed admits a 3-inch shaft for slotting. Cone has four changes, and is driven by a 4-inch belt. It is furnished with chuck and centers; the centers swing 12 inches and take a piece 14½ inches long. Weight, 5,700 pounds.

FLATHER & CO., NASHUA, N. H.

By combining the Whitworth quick return with the slotted lever crank motion, a more uniform cutting speed and also a very quick return movement is secured, without a shock or jar to the machine. A rack and pinion with a hand wheel on top of ram gives a most convenient and quick method for adjusting the ram to any desired position with the machine in motion or at rest.

The adjustment of stroke is obtained by the use of a scroll and rack instead of a rack and pinion. This device gives a quick movement, one that cannot slip under any cut, whether the crank-pin is tight or loose; furthermore the crank-pin can be tightened, thus adjusting the stroke very accurately while the machine is running at a high rate of speed or at a standstill.

They are also using a support for the outer end of "box-table," consisting of an angle piece fastened by two screws to the cross-rail, one end extending to the outer edge of box-table, and on which the box-table bears; the other leg extends downwards at an angle to the front of column where it bears on a rib cast on that part of column through which the raising screw runs. The rib is planed true with the face of column, and the angle being connected with the cross-rail, it will be raised or lowered with it. The lower part of the angle will have a bearing on the face of rib and will not require loosening every time the position of cross-rail is changed. The adjustable slotted lever is another device worthy of special mention, as by it the wear of lever can be adjusted and still retain its rigidity. This is accomplished by inserting a strip of metal between two lugs cast on the lever over the center of the slot and tightened on the strip by screws. As the slot wears away the metal strip can be taken out and enough dressed off to again make a good fit. A graduated collar shows the travel of ram. Most of these special features are patented.

FOX MACHINE CO., GRAND RAPIDS, MICH.

This machine is entirely different from the usual type, as will be seen by an inspection of the illustration. The ram is driven by the slotted arm D, which connects with the ram by pin H, the stroke being varied by shifting the fulcrum A either up or down; the dotted circles B and C showing the lowest and highest positions and consequently the longest and shortest strokes. This is adjusted by the rack and pinion movement shown in the photo-

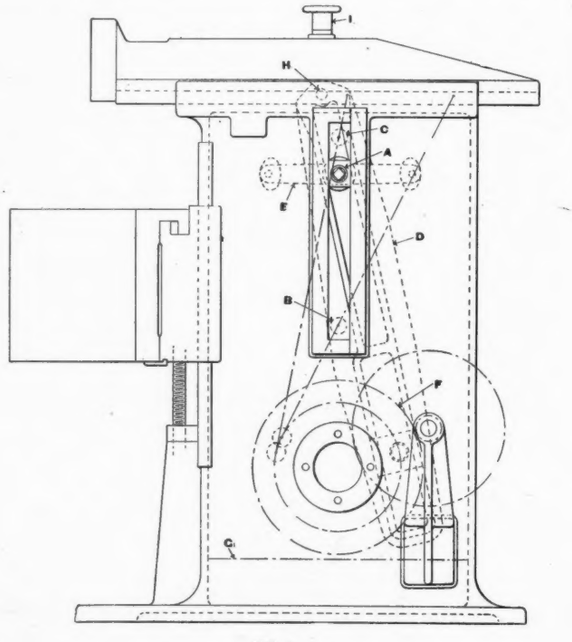


FIG. 3.

graph. The slotted lever dips below the oil line at G, and throws the oil up on the sliding block, crank-pin, gears and bearing, insuring easy running. The ram can be adjusted while running, as in many other machines.

As the crank-pin always has the same travel the wear on the pendulum is always the same, which is an advantage. Another feature of this arrangement is, that instead of having a forked connection between the ram and the top of the pendulum, there is a ⅞-inch steel pin, as indicated at H. This pin is in the under side of the nut and the pendulum is supported from it. This makes a very close connection and is not liable to much wear.

In order to make the pivot shaft firm it is encircled by the yoke E. This is fitted in accurately between the gibs and the column, so that in clamping the pivot shaft in position by the hand wheel it prevents the collar being forced together. This yoke is also bolted together at each end and takes the longitudinal thrust caused by the pressure which the tool exerts in performing the work. This makes the pivot shaft very rigid and firm. The position of the shaft can also be changed by slacking the binding screw I; then by the handle connected with the bevel gears which are shown near the head of the ram in the photograph, the nut can be traversed back and forth on the screw, enabling the operator to set the tool at any point of the stroke without leaving his position or stopping the machine. The table can be removed entirely from the saddle, or it can be tilted at an angle so as to plane taper work.

GOULD & EBERHARDT, NEWARK, N. J.

The illustration shows a 16 to 24 inch shaper, which is the latest pattern of this well-known make. The base is heavy and has a raised edge to prevent oil and waste from getting on the floor. The front part of base is planed to allow the table support to slide on it, and may also be used to bolt work to, in which case a special traveling head is added to the ram. It also allows a substantial support to box, angle or vise, which is very advantageous on heavy cuts, and insures more perfect work.

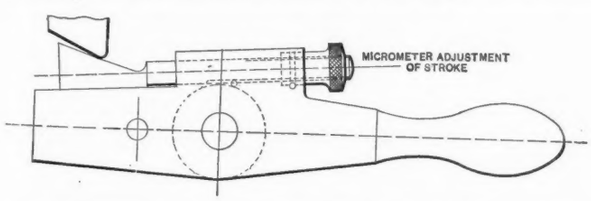
The machine is driven through two sets of gearing, one train being used for short and the other for long work, and both are under control of the lever shown at the back of machine. The makers claim that this gives about double the number of strokes that is obtained from any other construction. The length of stroke is readily adjusted by a crank-handle to any desired distance, an index making this a certainty. A slotted fork and link connect lever to the ram, and the latter is clamped to driving motion by handle shown on top. The length of stroke is positive and will plane to a line and under washer. The ram is extra heavy, of girder section, very stiff and not likely to spring under a heavy cut. Feed motion can be changed without stopping machine.

The crosshead slides vertically on a flat surface, the bolts passing through the frame, so that it is not sprung by any undue tightening of bolts. The slide travels from end to end and then stops automatically. The slide is protected from dirt and chips coming between crosshead and frame when bolts are loosened by the guard shown. This aids in keeping the sliding surface and vise in perfect alignment. The vise is of solid construction of good charcoal iron. A pair of adjustable centers are provided on each vise for small round work, such as fluting taps, reamers, etc. The jaws project to hold long or short work. A spot is cast on the vise for tapping it into fine adjustment, saving the vise and preventing bruises on the bearing portions. This was illustrated in our March issue and need not be repeated. The vise is also provided with a graduated nickled index plate under it.

The table is of box section and very rigid, and by a recent construction the vise can be fastened to its side. Automatic oil reservoirs are provided in all large bearings, insuring perfect lubrication. Shelves for tools are liberally provided and aid in keeping a shop neat as well as in economizing time. The countershaft is provided with a brake to stop machine instantly, which is often very desirable. The numerous attachments allow a large variety of work to be done, but lack of space forbids their being shown at this time.

THE HENDEY MACHINE CO., TORRINGTON, CONN.

This is now made of the friction type, having a friction clutch in place of the shifting belts formerly used. The use of belts has been discarded on all sizes. It is well known in tool room work. Probably the most distinctive feature of this shaper is the micro-



meter adjustment for regulating the length of stroke. This is shown in the line cut of the adjustment, in which the wedged shaped piece, or tappet, is adjustable by the thumb-screw shown, a very fine graduation being easily obtained. As this determines the length of stroke, it will be readily seen that it is comparatively easy to follow an irregular outline, which is particularly desirable on some die work. A neat little device is used in connection with the belt shifter which keeps the frictions in place until the shifting occurs. It is simply a flat spring with a V notch, one position being "in" the other "out" and holding the frictions in place. There is also an adjustable table, which is very handy for taper work. There is also an opening under ram for long shafts.

NEWTON MACHINE TOOL WORKS, PHILADELPHIA, PA.

There is little to be said in connection with this machine, as the photograph tells the story quite plainly. It is designed for shaping out the inside of locomotive driving boxes. The Whitworth crank and quick return is seen at the rear, the position of ram being adjusted by means of slot in end of connecting rod. The cutter bar has a rotary motion and feeds around the inside of box automatically. The box is placed on the angle plate, which is shown on the knee and which is adjustable in all directions. They are of very heavy design, as the illustration shows and are, of course, built to facilitate work in railroad shops, being in reality a special machine.

NILES TOOL WORKS, HAMILTON, OHIO.

The machine shown is provided with two double heads, although they are of course made with only one if desired; a double headed one being very valuable for certain classes of work. We regret not being able to obtain details, altough a general description is interesting and covers most points.

The cutter bar of this machine has a stroke of 18½ inches and is provided with Whitworth quick return. The ram has large bearing surface on the saddle and the heads 9 feet longitudinal traverse on the bed. This traverse can be made of any length desired. The driving cone is provided with four steps of ample width and diameters and countershaft has two speeds, giving eight changes of speed to the cutter bar. Machine has cross, down, angular and circular feeds for convex or concave work, all of which are operated by power. It is provided with two tables which have independent elevating screws and which are operated from a convenient position. One table is arranged so that it can be removed and a swivel vise used, the latter better adapted for clamping certain kinds of work.

Centers are also provided for circular work and the machine is provided with self-feeding cone mandrel for the same purpose. The saddles have quick traverse on bed by rack and pinion. It appears to be complete in all its details, is substantially built and with the feeds and traverse provided it is adaptable to a very wide range of work.

PEDRICK & AYER CO., PHILADELPHIA, PA.

This is another distinctive shaper, known as the Richards open side planer or shaper and, as shown by the photograph, can plane almost anything you can back up to it. At first sight it seems as though the tool at outer end of arm would be sure to spring, but it is carefully proportioned to stand the strain and no difficulty is experienced in this respect. The saddle, to which the head and arm are firmly secured, is driven by a screw running the entire length of bed. By the use of high speed pulleys and shifting belts the use of gears is dispensed with and a smooth and quiet movement of the carriage is secured. Adjustable tappets on the belt shifting rods over the bed shift the belts for reversing, the desired return speed being secured by placing the required backing pulley on the countershaft.

The photograph shows a tool with a 10 foot bed which planes up to 30 inches in width, at work on the main bearings of a Ball engine at their works in Erie, Pa. Although, perhaps hardly a shaper, it shows the style of tool, which is the same in either case.

With the movable tool the weight, and consequently the friction and power required for driving, is practically the same at all times, regardless of the weight of piece being operated on, which is, of course, the same in all shapers.

PRATT & WHITNEY CO., HARTFORD, CONN.

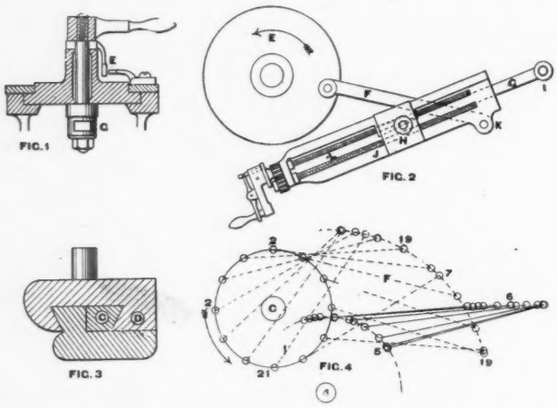
These tools are well known and need very little description; they are more especially designed for tool room work and are regularly made in but two sizes, 9 and 14 inches. The ram is adjustable for any stroke, has a uniform forward motion and quick return. All necessary feeds are provided and each machine is fitted with a Newell vise, which is also well known in connection with shaper work.

PRENTISS TOOL & SUPPLY CO., NEW YORK CITY.

The general design of this shaper is shown in the engraving,

the peculiar feature being the driving mechanism which is shown in the detailed drawings. Fig. 1 is a cross section of the ram, showing the clamping bolt and handle, which locks the link G in the desired position on the ram, a longitudinal slot enabling the relative position of ram and link to be varied at will. Link G connects ram to block H as shown.

Referring to Fig. 2 we have a plan view of the driving mechanism in which E is a worm gear running in the direction of the arrow. The link F connects this at D with the ram J, which carries the sliding block or nut A and the two screws shown. The ram is pivoted to the frame at point L, and the skeleton diagram Fig. 4 shows some of the positions assumed by the parts, in which I is represented by Fig. 6, K by 19 and 7, L by 4, H by 5, and operation can be followed so as to see the motion and quick return. The stroke is adjusted by changing the position of block H, which is readily done while the machine is in motion. Screw C (Fig. 3) controls the wedge in which it runs, and a turn in one



direction loosens it so the block H can be moved at will. The catch shown locks the gears and drives the other screw with the same handle. The stroke is shown by pointer at E, making accurate adjustment an easy matter. Fig. 3 shows the wedge C which locks block H (controlled by screw D) securely in any position. The advantages claimed for this are that there is no more pressure on main link F than that due to the cutting tool, the only wear likely to result in the other joints is due solely to turning of wrist-pin, and as links are all bushed with bronze the wear is slight. This arrangement is also claimed to preserve the same ratio of forward and back motion at all lengths of stroke, which is not the case with the sliding block. The feed mechanism is constructed so as to avoid bending and breaking of parts in case of any obstruction to table. Head is graduated and has a feed of 5½ inches at any angle. They are geared with a ratio varying from 13½ to 1 in the 12 and 14-inch machine to 22½ to 1 in the 26 and 28-inch machine, which makes them capable of heavy work. They vary in weight from 1,100 pounds for the 12-inch machine to 3,200 pounds for the 28-inch.

SPRINGFIELD MACHINE TOOL CO., Springfield, Ohio.

This is of the crank driven type, great simplicity and durability being among its claims of merit. High belt speed is used, giving sufficient power, while the gearing is amply strong for the work put upon it. All gears are cut from the solid, and this is also especially true of pinions which are cut in the ends of shafts having full diameter of outside of pinion. Automatic cross feed is provided in a very direct manner, as shown. The vise is solidly built, has graduated base and can be used on sides of box table if desired. The saddle and table are moved vertically by a rack and pinion instead of a screw, the pinion being controlled by a vertical worm, operated by the handle at back of carriage. A liberal bearing surface and careful attention to details makes this a very complete and substantial tool

GEORGE D. WALCOTT & SON, Jackson, Mich.

These are quite heavy tools, as will be seen from this photograph, the construction fitting them for the heaviest work. The ram is supported over the table to a considerable extent, 8 inches in their 34 inch machine; this stiffens the guides appreciably and does away with considerable spring, which is too often noticeable in shapers. As in most modern machines the stroke can be changed while running.

There is an opening under the ram for long shafts, as in a few other machines. Automatic cross feed is provided, as well as vertical and angular feed. The counter is arranged for two speeds, one for cast iron and one for steel, the regular speed for cast iron being 20 feet per minute, steel two-thirds as fast. The return speed is three to one. Details were not furnished.

* * *

STRENGTH OF HYDRAULIC CYLINDERS.

Juan de D. Tejada.

Under the general heading of "Hydraulic Cylinders" are classified all those cylindrical shells in which an uniformly distributed stress from within acts in first instance against the inner circular walls of the shell. The transmitting medium of the stress is a perfect fluid and the stress which in all hydraulic cases is a pressure, when at a point, is exactly equal in all directions. The stress is produced by the compression of the fluid against one or both ends of the cylinder and finally against the walls of the same. The compression of the fluid forces a closer molecular contact of its particles, and as a natural sequence a reduction in volume takes place.

The intensity of the stress is ascertained by a comparison between the units of force in action and those of the area of the vessel subjected to the stress. In modern hydraulic calculations, incompressible, non-vicous fluids only are considered, and among those the most perfect—water—the whole foundation of hydromechanics is taken as standard. In a hydraulic cylinder the material is subjected to a pressure from within and to a circumferential pull if the radius of the cylinder is large compared to the thickness of the shell. In this case the stress or circumferential pull is supposed to be uniformly distributed over the periphery of the shell that is around the walls of the cylinder. If the thickness of the shell is large compared to the radius of the cylinder, then a radial stress—the pressure—is acting gradually from layer to layer of the metal against the walls of the cylinder, and as the intensity diminishes, the circumferential pull towards the outside diminishes also. If the cylinder, however, has free ends and thick walls, although the two stresses radial and circumferential are acting against the walls, the former only is taken into account.

Fluids possess elasticity of volume only, and of these, as it will be shown later on, water has a very limited scope, and when uncompressed possesses no elasticity of figure or rigidity at all. As in an incompressible fluid exactly as in all fluids in general, any tangential stress, however small, produces a permanent deformation and eventually a radical change of shape, all the calculations for hydraulic vessels are based on internal stresses, dealing only as far as the fluids are concerned, with the following properties: Compression, compressibility and elasticity, or resilience of volume.

Water, which is one of the substances most necessary to animal life, is lavishly distributed all over the globe, and is a permanent, perfect fluid, practically non-elastic when under pressure, and unalterable in its chemical composition by any mechanical action. Water, as many other liquids of corresponding density and contrary to all solids, has such adaptation to change of form that when acting on its natural medium, atmospheric pressure fills all the interstices of the vessel in which it is confined, exerting an equal pressure at every point, and in whatever direction or side. Under a pressure of 30000 pounds per square inch water will reduce its bulk about $\frac{1}{15}$ of its original volume, and will assume the latter as soon as the pressure is relieved. Any amount of water, however small, will, by the use of proper contrivances, counterbalance and overcome the resistance of any other amount infinitely greater.

One cubic foot of water is usually rated at 62 pounds at a temperature of 52 degrees Fahr. A cylinder one foot in diameter and one foot long will hold 48¾ pounds of water at a temperature of 62 degrees Fahr.

The molecular nature of the particles of water has a great cohesic affinity, their atoms endeavoring to be always in contact. Under a pressure of about 9500 pounds per square inch water will ooze through a sound cast iron shell 8 inches thick and at a pressure of 220 pounds per square inch through a shell ½ inch thick.

On calculating the strength of cast iron cylinders of thick walls care should be taken of two important questions. The first one is the irregularity and lack of uniformity with which a thick cast iron cylinder is cooled, which makes them comparatively weaker than thinner ones. Iron for thick cylinders should be of the best

No. 2 medium grade Hanging Rock, and should be remelted three to four times to insure a tensile strength of about from 25,000 to 30,000 pounds per square inch. Taking this precaution, however, no rule will hold good in practice for cast iron cylinders whose thickness is more than from 8 to 10 units of the inner radius. Irregularities arising from air bubbles, sand holes and imperfect ramming of the sand in the mould is another serious objection, to avoid which, as much as possible, no cylinder for hydraulic work of any consideration should be cast horizontally, but vertically. The second question to be considered is, that beyond certain limits any increase in the thickness does not increase any the strength of the cylinder, because at this point the stress stretches the inner layers of the cylinder, and any strain however small will be followed by a molecular separation of the material and the subsequent bursting of the cylinder. In practice the limit is taken—although never carried to such extreme—when the stress equalizes the tension, which for cast iron is rated at 10 650, and for steel 36 000 pounds per square inch. For extraordinary high pressures, strength is given to the cylinder by forcing annular rings of a stronger material on the outside of the cylinder, thus compressing the inner walls of the cylinder. The rings are either shrunk hot or are forced by hydraulic pressure. Generally they are made of wrought iron ore machine steel. The stress within the cylinder has to overcome first the compression made by the rings and subject in the cylinder to its natural condition before any molecular separation could take place.

In hydraulic calculations the tensile strength of cast iron is taken at 18 000 pounds per square inch, and that of steel at 70 000. It is obvious to state that the word *diameter* always means in hydraulics *inside diameter* if not otherwise specified.

In regard to steel for hydraulic cylinders, only open hearth basic steel drawn tubes should be used specially for thin shells, as steel castings are not reliable. We have heard quite often the statement that good charcoal iron welded tubes are equal if not superior to steel ones. There is nothing, however, more erroneous than such an opinion; as a charcoal iron tube, no matter how well made, will not stand the severe tests to which open hearth steel tubes are subjected. The material of steel tubes is perfectly homogeneous and the product is perfectly uniform; the percentage of sulphur and forcing matters being very low. Good hydraulic steel tubes are in the market which answer very well for ordinary requirements. In a chemical analysis made some time ago of a piece taken at random, the following results were obtained: Carbon, 0.008; sulphur, 0.046; phosphorus, 0.025; manganese, 0.487. It will be seen that there is nothing in its chemical composition injurious or detrimental to the life of the pipe. As to the mechanical test it was satisfactory in every respect.

The writer has had for a long time the hope that a plain, concise treatise on hydraulic calculations, if published, was to be welcomed by the profession, but his desire has not been gratified up to date. The little information he has found in different authors, in plain arithmetic, or in elemental algebra, is so meagre and contradictory that he thinks better they were never interwoven in their works, and thinks also the public would have been better off. On the other hand the superb demonstrations and analytical calculations of Lame, Lagrange, Brix, Barlow, Greenhill and Ewing are of such high mathematical field as to render them inaccessible but for accomplished mathematicians not to be found in the general workshop.

The following rules, extracted from Lame's masterly works and put into plain arithmetic as far as possible, have always given me satisfactory results. A little care, however, should be taken on using them, and special attention should be paid to the setting of the decimal point.

RULE I.

Having the inside diameter of the shell. To find what thickness of a given material should be given to a hydraulic cylinder to stand a given pressure per square inch:

Divide the tensile strength of the material in pounds per square inch by the factor of safety required. The quotient will be the safe cohesion and the base of all further calculation. Divide the pressure in pounds per square inch by above safe cohesion. Multiply half of the quotient plus 1 by the quotient and multiply the product by the inner radius. The product will be the thickness of the shell in inches.

RULE II.

To find what internal pressure a cylinder will stand, the inside diameter and the thickness of cylinder being given; the factor of safety being 4:

Multiply one fourth of the tensile strength of the material in pounds per square inch by the thickness of the shell in inches and divide by the inner radius of the cylinder in inches. The quotient will be the safe pressure. Bear in mind that in hydraulic calculations generally, the lowest factor of safety is 4 and most common from 6 upwards.

The lack of space prevents me from treating any further on the subject. What has been said, however, is enough to make the above rules clear to the beginner.

* * *

LABOR'S VALUE,—2.

W. S. ROGERS.

Then we have the differential rated piece-work. There is a maximum, medium and minimum amount of work to be performed in a certain length of time, and the prices are rated differently according to the quantity and quality of the work completed. The results on pay day generally depend upon the "pull" one has with the foreman or inspector, and whether the duties of inspection take place before or after dinner. To keep correct and clear cost records considerable clerical work is required, and the opportunity for the young clerical man with hobbies of system and method all worked out in tabulated mysteries, intelligible only to himself, to get in his oar and work up a piece-work and cost department for you, is excellent. A few examples of differential piece-work will make it plain and show it to be as my foundry friend says, "the same old iron hands with new gloves on."

FOUNDRY.

October 10th.

GOSS. } *Molders.*—Put up; 40 plows.
MACY. }

PRICES: All good, 10 cents each; not good, 8 cents.
TIME 10 hours. Prices, if short, 7 cents.
RESULT: 36 plows × 7 = $2.22.

FOUNDRY.

October 11th.

GOSS. } *Molders.*—To put up; 40 plows in 10 hours.
MACY. }

PRICES: All good, 10 cents; some bad, 8 cents; short, 7 cents.
RESULT: 40 up, 9 bad. Wages, 40 × 8 = $3.20.

Then we found it was not quite honest and the cards on the ensuing work read as follows:

FOUNDRY.

October 12th.

WILSON. } *Molders.*—To put up; 40 plows in 10 hours.
MACY. }

PRICES: All good, 10 cents; some bad, 7 cents; short, 8 cents.
RESULT: 40 up, 10 bad. Wages, 40 × 7 = $2.80.

FOUNDRY.

October 13th.

RYAN. } *Molders.*—To put up; 40 plows in 10 hours.
ROELKER. }

PRICES: All good, 10 cents; some bad, 7 cents; short, 8 cents.
RESULT: 43 up, 5 bad. Wages—

Alas, the learned doctor who invented this hobby had given us no rule covering this case and we were lost. He had based his theory on the maximum capacity of the man, forgetting that the

human being is not a Seth Thomas clock, but varies according to the weather and the hours he keeps.

The owner of the plant agreed with me that it was only a sofa chair theory tending to create discord between his men and himself and it was abandoned. Molder Macy asked me a week later: "Phat ud yez do wud the bad plows yez skhinned the prices on?" "Scrapped, wern't they?" I answered. "Begorra, no," he replied, "I watched thim painted un shipped. Oh, it is a skinnin' plan, an a month av it wud made a sthrike sure." And my conscience agreed with him. I've tried it as an experiment several times with the same result. We must always remember that the "carriers of water and hewers of wood" have as keen a sense of justice as the overseer, and they are watching him all the time.

My friend, F. A. Halsey, at the Providence meeting of the American Society of Mechanical Engineers five years ago, contributed a paper on what he termed the "premium plan" of paying employees, and although it was not new, possibly he was the first to bring it broadly before the public, and always anxious to have the best of anything that will save worry and trouble, I began experiments with it, and really it is the only way I know to bring cordiality and harmony between everyone, provided it is in the hands of HONEST men.

The method is very simple, and not only reduces cost of production to minimum but also obviates all superfluous clerking and elaborate methods of book-keeping. While the superintendent can tell every week if desirable whether the cost is increasing or not, and the manager can know as soon as a piece of work is finished just what it costs, it is also so feasible that it will apply to any kind of work, manufacturing or otherwise, and makes every man carrying a ticket co-operative with the firm in reducing expense. In this method, the all important item of *saving time* is kept in view and the value of time saved shared with the workman, who draws his margins added to his regular pay on pay days.

A time limit is fixed by the superintendent or foreman on each piece of work to be done, and for every hour saved under that limit the workman gets a percentage of the value of the hours saved, or, in other words, he is paid his regular hour rate for the hours he *works* and is also paid a fixed per cent. for the number of hours he *doesn't* work under the fixed limit.

I have found by experience that a limit once set on a piece of work should never be cut or changed, neither should the per cent. or premium rate of a workman be altered. If this is allowed, the same feelings of suspicion and crookedness are apparent as we all know exists wherever "piece" or "contract" work is in vogue.

Neither would I advise giving each individual a separate premium card to carry in his pocket. It may look smart on the part of a superintendent or cost clerk to do this, but the workmen soon find each others rates, and if there is a variation, suspicion is aroused and union destroyed. Especially is this so in plants where rank favoritism has existed on piece-work. Here are examples showing reductions in time and cost:

PREMIUM FOR TIME SAVING PLAN.

BASED ON 33⅓ PER CENT. OF THE WORKMAN'S HOUR RATE FOR EVERY HOUR SAVED.

Items.	1st time.	2d time.	3d time.	4th time.	5th time.
Estimated time	10 hrs.	10 hrs.	10 hrs.	10 hrs.	10 hrs.
Hourly rate	30 cts.	30 cts.	30 cts.	30 cts.	30 cts.
Actual time	8 hrs.	7 hrs.	6 hrs.	5 hrs.	4 hrs.
Actual earnings	$2.40	$2.10	$1.80	$1.50	$1 20
Time saving rate (per hour)	10 cts.	10 cts.	10 cts.	10 cts.	10 cts.
Time saved (in hours)	2	3	4	5	6
Premium earned	.20	.30	.40	.50	.60
Total wage cost	$2.60	$2.40	$2.26	$2.00	$1.80

Every time the man adds 33 1-3 per cent to his wages per hour, he saves the company 66 2-3 per cent. of his hour rate, giving in addition the increased free time of the machine.

PREMIUM CARD. STEAM PUMP WORKS.

S. O. No. ———— Employee No. 31.
DATE, August 16 and 17, 1895.

Name of part, 7-4⅛-5 steam cylinders.
Number pieces, 1 pair.
Kind or work, boring.

Requirement Items.	TIME. Hrs.	Mins.	No. 126. Premium Rate.	Premium Earned
Commenced	4	20		
Finished	8	15		
Time limit	3	20		
Actual time	2	25		
Time saved		55	10	$.09

Correct, J. GEARY, Foreman.

Received, J. S. C., Clerk.

☞ No premiums allowed until work is delivered in stock room or accepted by cost clerk.

PREMIUM CARD. STEAM PUMP WORKS.

S. O. No. ———— Employee No. 117.
DATE, August 16, 1895.

Name of part, 7-16 piston-rod nuts.
Number pieces, 400.
Kind or work, facing.

Requirement Items.	TIME. Hrs.	Mins.	No. Premium Rate.	Premium Earned
Commenced	7	30		
Finished	10	..		
Time limit	20	..		
Actual time	12	30		
Time saved	7	30	5	$37

Correct. K., Foreman.

Received, SMITH, Clerk.

☞ No premiums allowed until work is delivered in stock room or accepted by cost clerk.

PREMIUM CARD. STEAM PUMP WORKS.

S. O. No. ———— Employee No. 120.
DATE, August 15 and 16, 1895.

Name of part, 2½ inch spools.
Number pieces, 189.
Kind or work, milling.

Requirement Items.	TIME. Hrs.	Mins.	No. Premium Rate.	Premium Earned
Commenced	3	45		
Finished	5	..		
Time limit	15	..		
Actual time	11	15		
Time saved	3	45	06	$22

Correct, K., Foreman.

Received, J. S. C., Clerk.

☞ No premiums allowed until work is delivered in stock room or accepted by cost clerk.

MACHINE WORKS.

PLANING TWO SPINDLE CAPS.

TIME.	Hrs.	Prices. Rates.	Earnings. $	cts.
Limit	10			
Actual	4	18	..	72
Premium	6	8	..	48
Employees wages			1	20
Cost per piece				60
Previous contract price				70

MACHINE TOOL WORKS.

TURN, THREAD AND FINISH TWO CLAMPING SCREWS.

TIME.	Hrs.	Prices. Rates.	Earnings. $	cts.
Limit	14			
Actual	8	22	1	76
Premium	6	10		60
Employees wages			2	36
Cost per piece			1	18
Previous contract price			1	50

MACHINE TOOL WORKS.

TURN AND FINISH THREE LARGE SPINDLES.

TIME.	Hrs.	Prices. Rates.	Earnings. $	cts.
Limit	27			
Actual	15	22	3	30
Premium	12	10	1	20
Employees wages			4	50
Cost per piece			1	50
Old price			1	75 each

ELECTRIC AND MANUFACTURING CO.

CLEANING 5,400 PIECES OF BRASS CASTINGS.

Employee, THOS. MUMFORD.

Began, December 2, 1895. Ended, December 6, 1895.

TIME.	Hrs.	Prices. Rates.	Earnings. $	cts.
Limit	54			
Actual	40	17½	7	00
Premium	14	7		98
Employees wages			7	98
Cost per pound				14⅞
Previous price, per pound				17½
Man's hour rate				15
Man's earnings per hour (almost) by premium				20

The rule is, that the more wages the employee earns the less the cost of labor is, and no clubs are needed or pruning knives in the hands of "rate fixers" to keep up constant discontent, but

every man or woman is planning how to scale the actual time down and thus raise their hourly profits.

"Smart Alecs" (excuse the term, but it expresses the idea plainest in shop lore) generally get this method tangled up, and then we hear of its being a failure because "the plant was too large" or the work was not suited for it, while the real truth is, it is in the hands of one who knows it all and doesn't know anything.

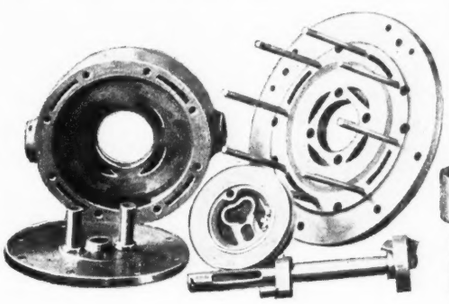
In the sixth line of the fourth paragraph, in the first column of page 225, April issue, the word "employes" should be "employers;" the error was so plain, however, as to cause no misunderstanding.

THOMAS H. WATSON.

Thomas H. Watson, of Watson & Stillman, died on April 6, at his home, 411 Lexington avenue, New York City, from inflammation of the brain, following a severe cold contracted about two weeks previous. He was born in England, in 1836, but came to this country with his parents when he was two years old. After an apprenticeship in an East side machine shop in Sheriff street, New York, he became foreman for the firm of Dudgeon & Lyon, about forty years ago. This firm was dissolved in 1860, and Mr. Watson became superintendent for Eliphalet Lyon, the surviving partner. In 1876 he became a partner in the firm of E. Lyon & Co., the other partners being his former employer and Francis H. Stillman. On the death of Mr. Lyon, in 1883, Mr. Watson and Mr. Stillman formed the firm of Watson & Stillman, at 470 Grand street, moving to their present quarters, 210 East 43d street, about 1885. Mr. Watson had not been actively engaged in the business for the past two or three years.

THE KNICKERBOCKER ENGINE.

After over four years of quiet work, experimenting, testing and perfecting this engine, the makers are now ready to put them on the market with their full guarantee, believing that they have overcome every fault, and that the test engines which have been running for over two years sustain this belief. These engines have not had the cover off for adjustment of any kind. It was first conceived as a boat engine, which should have no dead centers, and which could be operated from the steering wheel or any other part of the boat. The makers wish it understood that it is not a new fangled engine, but one which embodies the same principles as the ordinary horizontal engine, the difference being in applying this power to the main shaft.



The pistons are free to turn so that they can rotate at each stroke and thus wear round. There are four small cylinders, as will be seen in Fig. 1, which shows the parts of a simple reversing engine. Pictures tell their story more plainly than words, and these show the mechanism quite plainly.

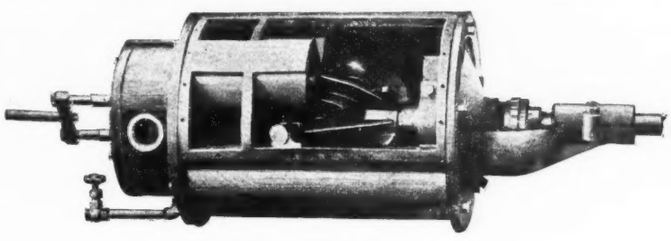


FIG. 2.

Instead of the crosshead running back and forth on long ways, it is hung at the end of the cylinders on a large ball and socket connection. Piston-rod connections with the crosshead are all ball and socket connections, so when each piston in rotation pushes on the crosshead, the crosshead describes the surface lines of a cone whose apex is at the center of the universal connection. The crank-pin being the further extension of the crosshead takes this motion and has a constant application of the push of one and a half to two cylinders during the full revolution, and is pushing one way all the time. The engine runs noiselessly, has short connections and not much weight to throw, which can be thoroughly balanced, and the stroke of engine piston being only one-quarter of the entire stroke, the engine can be run at a high speed. Having the motion made by the engine in mind, it will be noticed that all the connections have only a movement resembling the figure 8; that is that no two lines can ever run parallel, but must cross and recross; or the connections have only a polishing wear.

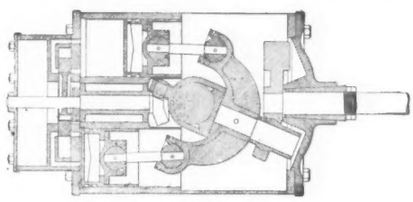


FIG. 3.

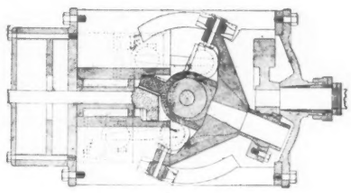


FIG. 4.

In the steam admission, the valve is a ring around the eccentric and loose; steam surrounds entirely the outer circumference, the eccentric attached to the valve shaft turns, but the valve *slides* on the eccentricity, covering and uncovering the ports with a sliding motion and not a center to center motion. The governor is attached directly to the eccentric and lies in the exhaust chamber adjoining the steam chest. The reversing gear takes the same position in the reversing engine; is simply a sleeve with a spiral slot and rim to catch a yoke. This yoke has a stem going out through the head; pull or push on this stem and the eccentric is thrown one way or the other across the center; when directly on the center the valve closes all the ports; when thrown to either side it opens or closes the ports with any cut-off wished from full to nothing.

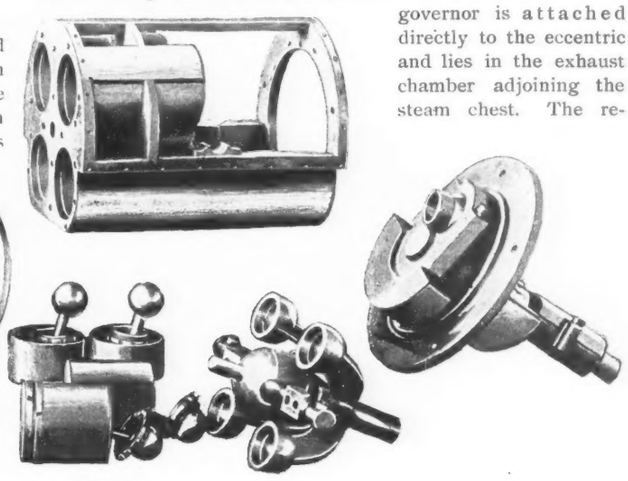


FIG. 1.

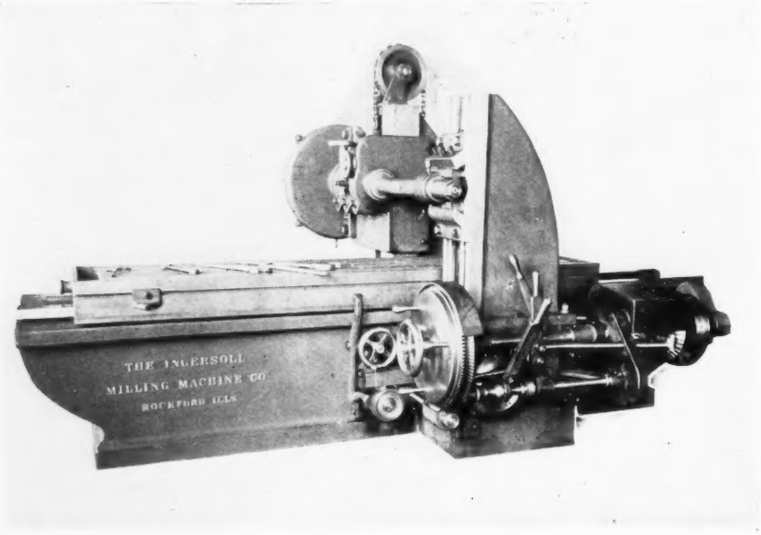
Taking as example the simple engine with 4½ inches cylinders and 4¼ inches stroke. This is 14 inches in diameter and 32 inches long over all, and should run at 600 to 800 revolutions, using any steam pressure wished, and there is the power of two double acting steam engines of the ordinary type of the same area, stroke, revolution and pressure. Figs. 2, 3, and 4 show the case removed, a section through cylinders and a horizontal section respectively. It is made by the Knickerbocker Engine Works, Hartford, Conn.

* * *

We are pleased to note the return of George A. Bernard, M. E., to his old post as New York representative of the Buckeye Engine Company, at No. 39 Cortlandt street. Mr. Bernard is a charter member of the A. S. M. E., and has a host of friends in engineering circles.

AN EXTRA HEAVY SLAB MILLING MACHINE.

The Ingersoll Milling Machine Co., of Rockford, Ill., are devoting their time exclusively to the type of machine illustrated, this being the smallest size of the slab milling machine which



EXTRA HEAVY SLAB MILLING MACHINE.

they build. Their years of experience with this line of machines prove that the necessary requisites for a slab milling machine are a powerful drive, and then plenty of metal so placed as to resist strains of the powerful drive.

The illustration shows their 20 inch by 7 foot slab milling machine. The spindle is worm driven, and has a long bearing in its saddle. All adjustments of the machine are made by the levers shown in photograph on the operating side. The lever nearest the operator raises and lowers the saddles by power, carrying the spindle and arbor support. The second or middle lever is for the power adjustment of the table in either direction. The third lever is to move the outside housing back out of its bearings, carrying the arbor support saddle. By this arrangement the machine is easily made open side. This makes the machine almost universal, as it can be used for facing off the ends of long pieces, cutting off long bars and a variety of such other work. An idea of the rigidity and power of the machine can be imagined, when it is known that this machine will take a cut in cast iron 20 inches wide and ¼ of an inch deep, at the rate of 5 inches per minute. This is not the maxim strength of machine, but it is what it can be depended on to do in everyday work. We are also informed by the manufacturers that they are building various sizes of slab milling machines with horizontal or vertical spindles, or both, ranging in widths from 20 inches to 100 inches.

There seems to be a tendency nowadays toward designing new work to accommodate the milling machine instead of the planer, and redesigning old work for the same purpose. We hope soon to furnish our readers with other illustrations of the machines made by this company, as we think they will be of interest to every one.

* * *

A RECENT advertisement for an efficient foreman contained the stipulation that no one "at present out of employment" need apply, as they only wanted men who held good positions and wanted better ones. This was evidently written with the idea that no man competent to fill the position would ever be out of employment. We believe this inference to be wrong in many cases, and know of more than one man who is at this writing without regular employment, through no fault of his own, who would be a valuable man for any shop.

* * *

ROOM FOR IMPROVEMENT—SUGGESTIONS.

Editor, Machinery:

Not long ago one of our customers called our attention to a certain machine we sold him, whereon a certain vital piece was furnished of malleable iron by the maker. The piece had given out, and our customer had made a new piece of machinery steel, and strengthened it, much to the advantage of the whole structure. He called our attention to it and suggested that we notify the builders, and we did so. Instead of thanks for our trouble, we were told that the machine as they made it was all right, and had been made that way for a long time, etc., etc. Now we believe that "the largest room in the world is the room for improvement." *We know* that frequently the purchaser of a machine finds it necessary or to his advantage to make changes or improvements on it and never says a word about it to the maker, and if *we* were manufacturing anything we should solicit the opinions of practical men, and try to profit by them.

Against and in contrast with the treatment mentioned herein, comes a little incident related to us recently.

The proprietor of a large wood-working establishment visited the factory of a manufacturer of machinery in his line. After a short chat with one of the head men he was asked to take a stroll with him through the works. A young gentleman stenographer accompanied them. The visitor was frequently asked his opinion of certain points on the machinery, and he noticed that notes were made by the stenographer. Some months after he bought a certain machine from this concern, and was both surprised and gratified to find that one of his suggestions had been carried out by the manufacturer.

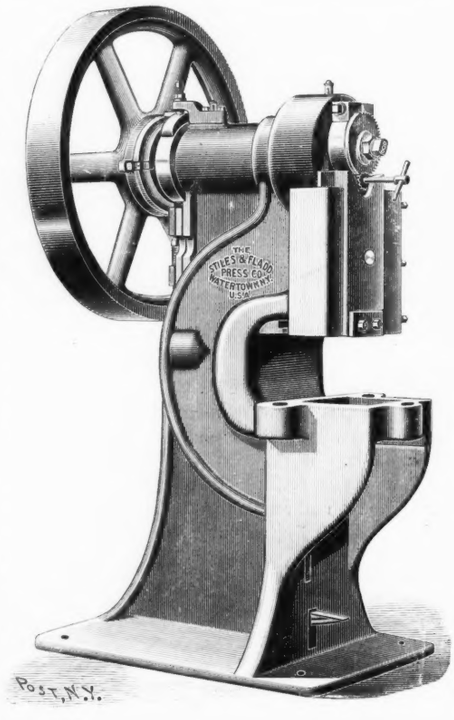
We are always glad to receive suggestions. It does not necessarily follow that all of them are practicable or advisable to adopt, but we are always grateful for helpful criticism.

Dayton, Ohio. CALLENDER & PATTERSON.

* * *

THE STILES & FLADD PRESS.

There is no marked departure from existing design, and follows in a general way the lines of the well-known Stiles press, but in addition is said to embody several improvements demanded by the latest practice.



The makers lay special claim to excellent workmanship and the selection of the most suitable material for the construction of the press, a special mixture of iron being used in their castings. Long guides are provided to resist side thrust.

A new clutch, by the inventor of the original Stiles clutch, but superior to it, is used on these presses. This allows the press to be run equally well in either direction. It has three points of contact in the wheel, making it practically instantaneous, and allows the operator to make a whole revolution or any part of one he desires, lessening the liability to accident to both operator and tools. It can also be used to back out a punch which is stuck in the die. Fly presses are manufactured in six sizes, from 500 to 7 500 pounds in weight, and five sizes of geared presses are made, weighing from 1 200 to 8 000 pounds. The Stiles & Fladd Press Co., Watertown, N. Y., are the makers.

MACHINE SHOP ARITHMETIC.

A series of practical articles clearly explaining the portions of mathematics which will be useful to the men in the shop and engine room.

PRACTICAL QUESTIONS CONNECTED WITH THIS SUBJECT WILL RECEIVE PROMPT ATTENTION.

ARITHMETIC AND GEOMETRY.

JOHN H. COOPER.

Whatever diminishes the labor of calculations must be acceptable to some of your readers. The process here offered is not new in principle, but may be a novel one to many; it may have interest, as showing the connection and intimate relationship of arithmetic and geometry; that while the modes of working are so different, the principles and results are the same. Let us bring these seeming incongruities together to find their likeness, if they have any. For example: Let 83 be a number whose square is to be required. To facilitate calculation let us assume another number, say 3, and proceed upon the new way; then $83+3=86$, and $83-3=80$. The sum and difference; the product of which is 6880, to which add 9, the square of the lesser number 3, and we get 6,889, which is the square of 83.

If the number to be squared ends with 5, the process is still shorter. Suppose 85 be the number, then taking 5 for the lesser number, the sum and difference will be thus: $85+5=90$ and $85-5=80$; whence $90\times80+25=7\,225=85^2$, almost an easy mental operation.

The intelligent reader will perceive that in every case we save the trouble of multiplying by at least one figure, and in many cases of much more. For example, take the number 997; then $997+3=1\,000$ and $997-3=994$. By a mere mental process we obtain 994 009, the square required; that is, $994\times1\,000$, to which add 9.

Let us now turn to an elucidation of the principle by the method of geometry. A certain problem in Euclid's elements proves that the product of the sum and difference of two numbers is equal to the difference of their squares, to which difference, if we add the square of the lesser number, we obtain the square of the greater. Many readers, on hearing these words, would fail to see any point or value in them; yet the principle upon which the above solutions are worked out is embodied in this Euclidian statement, well nigh as "old as the hills."

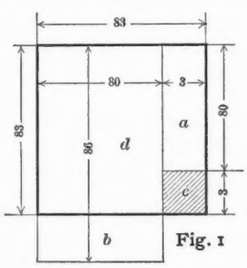


Fig. 1

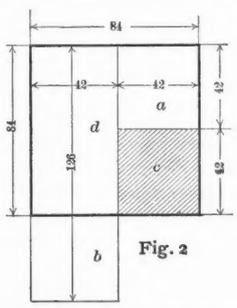


Fig. 2

To give you an ocular proof of this problem and avoid as much as possible the "dry as dust" methods of geometry, let me refer you to a diagram, like a machinist's dimensioned drawing, which will appeal to your common sense, as it meets your eyes; giving you a demonstration without words, and may be more convincing.

Look at the square, Fig. 1, having sides of 83 units. Now cut 3 units from one side and add 3 units on the bottom, and then make the side part *a* the same length as the bottom addition *b*. Complete the figure, which will leave the part *c* a square having sides of 3 units. You will plainly see that the product of the sum and difference of the two numbers will always make an area less than the square of the larger number by an area equal to the square of the lesser number; and consequently the square of the larger number is not complete without the square of the smaller.

There is another interesting feature of this problem and diagram that does not appear without being pointed out; that is the equal boundary of the two larger figures, thus: $4\times83=332$ and 2×80 added to $2\times86=332$; that is, the boundary of the square having sides 83 units and the boundary of the rectangle having sides 80 and 86 are equal.

The difference in their areas is the square of the lesser number, thus: $83\times83=6\,889$ and $80\times86=6\,880$, a difference between the two of 9, which is equal to 3×3. Therefore, if you wish to enclose the greatest space within four sides and with a given boundary, you must make it square. As you increase the size of the lesser number (see Fig. 2) you increase the area of the lesser square *c*, and as the sides of the rectangle *d b* differ, the area enclosed lessens, the two boundaries remaining always the same.

This is an object lesson in what is called Isoperimetrical geometry, or that which considers the relations of quantities having equal perimeters or boundaries.

Next, consider Fig. 2, in which the square is quartered, and then if we complete it, as in Fig. 1, the addition *b* will result in one of the quarter squares.

Supposing, in this case, the side of the square to be 84 units, that is the larger number 84 and the lesser 42, then the product of the sum and difference; that is, $126\times42=5,292$, which is but three-fourths the area of the square of 84, while their perimeters are the same; showing that with equal boundary, as the rectangle elongates, its area diminishes; and conversely, as it approaches the square in form, its area increases, becoming the greatest possible when all sides are equal and all angles are right angles.

The mechanical engineer certainly has much to do, not only with the shorter methods of calculation, but with boundaries and enclosed spaces, particularly when he has to furnish the boundary, or "bulk head."

Many times in his experience a knowledge of Isoperimetrical geometry would help him to the best solution—that in which the least material and workmanship will enclose a certain bulk or volume. I can therefore confidently recommend the subject of *Maxima and Minima* for his study, believing he will find it rich in interest and value.

* * *

THE FIRST PRINCIPLES OF MECHANICS.—7.

MOTION.

LESTER G. FRENCH.

Motion is a progressive change of position. We can judge of the motion of a body only by comparison with the position of some other body, which may or may not have the same motion. Motion, then, is a relative term. A railroad train running at 10 miles an hour has this speed in relation to the earth, but in relation to another train moving at the same rate on a parallel track, and in the opposite direction, its motion is at the rate of 20 miles an hour. A brakeman running from the forward to the rear end of a freight train at the rate of 5 miles an hour, might be moving with either a greater or less velocity than this when compared with the ground, depending upon the motion of the train; and if it should happen that the train was moving forward at the rate of 5 miles an hour, the man would appear stationary to an observer standing beside the track.

To put a body into motion, or to alter its motion, requires the expenditure of force, as is a matter of common observance, and a little consideration will show that the *tendency* of force is always to produce motion, or to modify it. In case the body acted upon is perfectly free to move, however, as is nearly the condition, for example, of a heavy ball suspended from the ceiling by a long wire, the effect will always be to actually produce motion, however slight the force. In that branch of mechanics called dynamics, which treats of the motion of bodies, we generally have to deal only with cases of this kind. Should it be necessary, however, to

take frictional resistances into account, we deduct that part of the applied force which is used in overcoming friction, and assume that the remainder of the force acts as though such resistance did not exist.

Velocity is the rate of motion. When speaking above of the train moving 10 miles an hour, or of the brakeman running 5 miles an hour, the velocity of the train or brakeman was meant. Uniform velocity takes place when equal spaces are passed over in equal times, and variable velocity when the spaces are unequal. In physical problems, velocity is generally expressed in feet per second, and in engineering work in feet per minute. Other units are also used, as when we speak of the velocity of a rai road train as being a certain number of miles per hour.

The velocity of a body is equal to the distance passed through, *uniformly* divided by the time. In problems in dynamics it is customary to speak of distance as space, and in conformity with this we will represent it by the letter S.

Let S = the space, or distance; V = the velocity and t = the time. Then,

$$V = \frac{s}{t} \quad (8)$$

Formula (8) may be re-written so as to find the values of s and t, thus: $s = V\,t$ and $t = \frac{S}{V}$

Example.—Sound travels through the air with the velocity of about 1 090 feet per second, and light almost instantly. If a gun half a mile away is fired, how soon will the report be heard after seeing the flash?

$$t = \frac{s}{V} \quad \frac{5280}{2 \times 1090} = 2.4 \text{ seconds.}$$

Acceleration is the rate at which velocity changes when it is variable, that is, acceleration is the change in the velocity of a body during a very short interval of time, as a second. Thus, suppose a body to have a velocity one second of 100 feet per second, and the next second of 110 feet per second. The acceleration is then 10 feet per second *in a second.* If it should require two seconds for this increase of velocity to occur, the acceleration would be $\frac{10}{2} = 5$ feet per second in a second, and if it should occur during an interval of $\frac{1}{4}$ of a second, it would be $10 \div \frac{1}{4} = 40$ feet per second in a second. When motion decreases instead of increasing, it is called *retarded* motion.

An important application of accelerated motion is found in the case of bodies falling under the influence of gravity; this will be taken up later. A body falling freely from rest to the earth acquires during the first second a velocity of about 32 feet per second; at the end of the second second a velocity of about $32 + 32 = 64$ feet per second; at the end of the third second a velocity of $64 + 32 = 96$ feet per second, and so on. It is thus a case of uniformly accelerated motion. This acceleration, due to gravity of 32 feet per second in a second (32.2 more exactly for the vicinity of London and 32.16 for the vicinity of New York) enters so much into calculations that it is customary to always represent it by the same letter—the letter g.

MASS.

The mass of a body is the quantity of matter that it contains. We are accustomed to think of the weight of a body as a measure of its mass. When one speaks of a ton of coal, the word ton conveys at once an idea of the quantity of coal that is referred to. We know, however, that weight varies with the locality, decreasing as we go above or below the sea level, and increasing in passing either north or south from the equator. This fact was briefly explained in the second article in this series. The variation is slight, and in any case could not be detected with the ordinar balance scales, but it neverthe.ess exists. If a load of coal should weigh 2,000 pounds at the sea level on a pair of platform scales, and should then be drawn to the top of a mountain a mile high and similarly weighed, the scales would again balance at 2,000 pounds, because any variation in the attraction ot gravity between the two places would affect the counterpoise of the scales in the same ratio that it affected the body weighed. But if the coal were weighed in a large spring balance, it would be found to weigh only about 1 999 pounds on the mountain top; yet it is perfectly plain that the quantity of matter in the coal would not be altered in any way by the journey. We thus see how easy it is, and also how erroneous, to form the idea that weight is a correct measure for quantity of matter or mass.

To obtain a numerical expression for mass, divide the weight of a body as determined by a spring balance g, by the acceleration due to gravity at that point; or for practical purposes, the weight as determined by a pair of good scales by 32.16. Expressed as a formula:

$$\text{mass} = \frac{\text{weight}}{g} \quad (9)$$

This expression fulfills the condition required; namely, it gives a constant value, wherever the locality. Weight varies directly as the force of gravity, and so does the value of g. Hence. if the weight and g are both determined at the same place, their ratio will be constant for all places. Thus the mass of a 100 pound weight $\frac{100}{32.16} = 3.11$ pounds. On the surface of the sun, where the force of gravity is 28 times as great as here, the same object would weigh 2,800 pounds, but its mass would be $\frac{28 \times 100}{28 \times 32.16}$, or 3.11 pounds as before. It will be observed that both mass and weight are taken in pounds. This double use ot the word pound is customary, though sometimes ambiguous. Mass is an important factor in the study of motion.

NEWTON'S LAWS OF MOTION.

The first clear statement of the fundamental relations existing between force and motion was made in the 17th century by Sir Isaac Newton, the English mathematician and physicist. It was put in the form of three laws, which are given as originally stated by Newton:

I. "Every body continues in its state of rest, or uniform motion in a straight line, except in so far as it may be compelled by force to change that state."

II "Change of motion is proportional to the force applied and takes place in the direction in which that force acts."

III. "To every action there is always an equal reaction; or, the mutual actions of two bodies are always equal and oppositely directed."

Law I.—The first law is known as the law of inertia and it is, in fact, a statement of the principle of inertia. Inertia is a general property of matter, that is, a peculiar quality possessed by all bodies, just as elasticity, hardness, ductility, brittleness, etc., are properties common to different substances. By virtue of this property called inertia, all bodies are compelled to remain at rest, when placed at rest, or in motion when placed in motion, until acted upon by some force. The term inertia means simply the inability of matter to change its state with regard to motion or rest.

The fact, as stated in the first law of motion, that any object at rest cannot of itself acquire motion, is a matter of every day observation. Whenever a body passes from a state of rest to one of motion, a cause can always be assigned for the change, such as a blow or a push or pull. The truth of the statement in the second part of the law, however, is not so easily grasped. It is asserted that a body once in motion will continue in motion, following the path of a straight line, unless acted upon from without, and it is implied that it is as natural for a body to continue indefinitely in motion as it is for it to remain at rest. Looking about, however, it will be seen that whenever the motion of a body is altered, or changes from a rectilinear path, it is because of outside interference. A ball, for example, when thrown from the hand, moves in a curved path and finally comes to rest because of the attraction of gravity and the resistance of the air. If the ball be rolled along the rough ground, its loss of motion is accounted for by the friction, for we observe that the smoother the ground the farther the ball will roll. Again, if we can conceive it possible that the ball could be hurled out into space away from these resistances, it is reasonable to suppose that it would go on forever.

The effect of inertia is also exhibited whenever we attempt to put a body suddenly into motion or to stop one already in motion. The quick start of a railway train throws everybody against the back of his seat, as we say, and in a similar manner the passengers are thrown forward when the brakes are quickly applied.

Law II.—The term "motion" as here used by Newton embraces all the elements that go to make up the motion of a body, and hence introduces both mass and velocity, or what is called *momentum.* The momentum of a body is measured by the product of the mass M of the body by the velocity V, or,

$$\text{momentum} = M\,V = \frac{w}{g}V \quad (10)$$

It is sometimes defined as the quantity of motion in a body. It is not a force, but rather the measure of the effect of a force in a given time, since to produce velocity in a mass requires time.

The second part of this law states that the motion takes place in the direction in which the force acts. From this follows the principle of the *independence of motions*, that when two or more forces act upon a body at the same time, each produces exactly the same effect as though it acted alone, whether the body be originally at rest or in motion. Thus, if a person threw a ball due north from the roof of a house, while the wind is blowing from the west, the effect of the throw in a northerly direction will be exactly the same as it would be if the air were quiet, while the distance that the ball is carried to the east will be equal to the distance that it would travel in the same time if it were under the influence of the wind alone, disregarding, of course, any unequal frictional resistances of the air. Moreover, as the ball leaves the hand, it will gradually drop to the earth under the influence of gravity, and it will take precisely as long for it to reach the ground as it would if it had been simply dropped from the edge of the roof. That is to say, the effect of the force of gravity is exactly the same as though it acted alone; each motion goes on independently, although the position of the ball at any time depends upon the action of all the forces acting.

Law III.—We have seen, under the subject of moments (January number), how the supports of a beam react with a force equal to the downward pressure of the beam. There are many other evident illustrations of this law. A ton weight hanging on a crane hook exerts a downward pull of 2 000 pounds, and the reaction of the hook and chain is also 2 000 pounds. When a horse pulls a cart there is the reaction of the load. In jumping from a boat the reaction shoves the boat away from the shore. A man cannot "lift himself by his boot straps," because the downward push, or reaction, is equal to the upward pull.

ANSWERS TO EXERCISE 6.

1. Work done = 2 500 foot-pounds. Work put in = $20 \times 2 \times 3.1416 \times 30 = 3769.92$ foot-pounds. Efficiency = $2\,500 \div 3769.92 = .663 = 66\frac{1}{3}$ per cent.

2. (*a*) The weight moves twice as far as the bar. Hence a weight of 125 pounds would be necessary to support the bar. (*b*) The same weight would answer. Notice that the pull at A = W; hence, if instead of being fastened at A the chain passed over the pulleys of a second head, the same conditions would hold for that as for the first head.

3. (*a*) Efficiency $= .75 = \frac{\text{work done}}{\text{work put in}} = \frac{W \times 1}{125 \times 4}$. $W = 375$ pounds. (*b*) Efficiency $= .65 = \frac{600 \times 1}{125 \times N}$. $N \times 125 \times .65 = 600$. $N = 74+$. Eight ropes would be necessary.

* * *

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

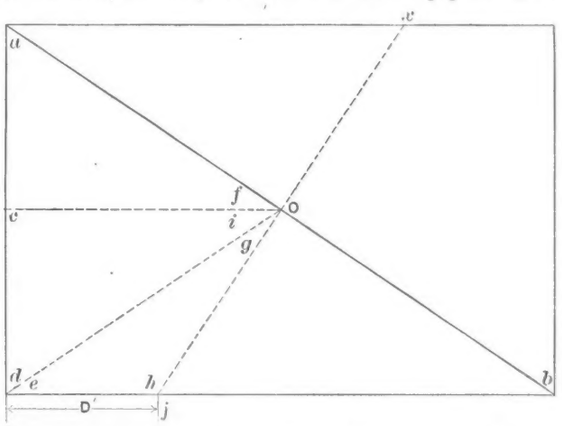
49. H. S. H., Saginaw, Mich.: Will you please inform me through your paper what is the technical name for the two pins on an engine? I think a crank pin, because anything with a crank usually turns 'way around; and a wrist pin, because a wrist only makes part of a revolution, as the wrist of a person's hand. *A.* Your side of the question seems to be well taken, and the terms you mention are probably the most used. Personally, we prefer to say "crosshead pin," as it prevents any mistakes.

50. S. B. T., asks: 1. What is squaring a valve? *A.* Setting it so as to give an equal distribution of steam in each end of cylinder. 2. An engine is said to have 10 per cent. clearance, what is it by measurement when if engine has 20 inch stroke? *A.* As clearance includes all the space between piston head and valve (when piston is at that end of cylinder) it cannot be expressed in inches of stroke, but must be in cubic inches, or volume of the space included. Assuming the cylinder to be 10 inches in diameter and not allowing for difference due to counter bore, we have the volume of cylinder as $10 \times 10 \times .7854 \times 20 = 1570.8$ cubic inches, and 10 per cent. of this is $\frac{1}{10}$ of $1570.8 = 157.08$ cubic inches, equivalent to 2 inches of the stroke. As it is probable the piston goes within ½ inch of cylinder head, and as ½ inch is ¼ of 2 inches, we see that ¾ of the clearance is in the ports in this case. This clearance is necessarily at each end of cylinder. 3. Which is more economical, large or small clearance? *A.* When we see that all this clearance space must be filled with live steam at each stroke, it is readily seen that the small clearance is the more economical, although it is impossible to bring this down below 3 to 5 per cent. in ordinary cases, in fact it may be said to vary between 2 and 7 per cent. with 10 per cent. as an extreme case.

51. L. O. C. You will find an article on "shrinking fits" in our April issue, the other we expect to treat on shortly.

52. J. Y. M. sends a sketch of two steam reservoirs, A and B, which are connected, the pressure in the former being maintained at 120 pounds per square inch and a partial vacuum exists in reservoir B. 1. Will the steam flow into B as fast or faster than it would into the atmosphere? *A.* Haswell gives a case where the rate of flow of steam into the atmosphere was about half the rate into a vacuum, with steam at 100 pounds. "Helios," Heine Boiler Co., says: "The flow of steam of a greater pressure into an atmosphere of a less pressure, increases until the external pressure becomes only 58 per cent. of the absolute pressure. The flow of steam is neither increased nor diminished by the fall of the external pressure below 58 per cent., or about ⅓ of the inside pressure." 2. Will the flow continue until the pressure in the second tank B, is $\frac{6}{10}$ of that in A? *A.* The flow will continue until the pressure in B equals that in A. The quotation from "Helios" refers to rate or speed of flow and not to the pressure.

53. W. S. D. writes: The opposite corners of a rectangular piece of paper are brought together and the paper creased; how can I find the distance (D′ in cut) from crease to end of paper? *A.* We



outline the mode of procedure. Refering to cut, *x j* is the crease formed by joining *a* and *b* and is, of course, at right angles with the line *a b*, which in turn is the hypothenuse of the rectangle. Knowing the length and breadth of the rectangle, we can readily find the hypothenuse by squaring the length and breadth, adding the squares and extracting the square root. Half of this gives the distance *a o* and of course *d o* also. The distance *a c* equals half the width of rectangle and forms the base of the right angled triangle *a c o*. The distance *c o* equals the square root of the square of *a o* minus the square of *a c*. The next step is to find the angle *f*. This is done by plain trigonometry, which says: The sine of an angle equals the opposite side divided by the hypothenuse or *a c* divided by *a o*. After finding the angle *f* add the angle *i* (exactly the same) and deduct from 90 degrees which gives the angle *g*, and finding the angle *a*, which is 180 degrees minus *f* + *c* (*c* = 90 degrees). Angle *d* equals angle *a*, and deducting this from 90 degrees gives angle *e*. Having angles *e* and *g*, we find angle *h* in the same way that we found angle *a*, then as we have the length of side opposite angle *h*, we follow the proposition that: "The sine of angle opposite given side is to sine of angle opposite required side, as the given side is to required side." This gives the proportion of, sine of angle *h* : sine of angle *g* :: side *o d* : the required side (D). This is quite a long operation, but is good practice in the use of plane trigonometry, although the question is not one which comes up in shop practice.

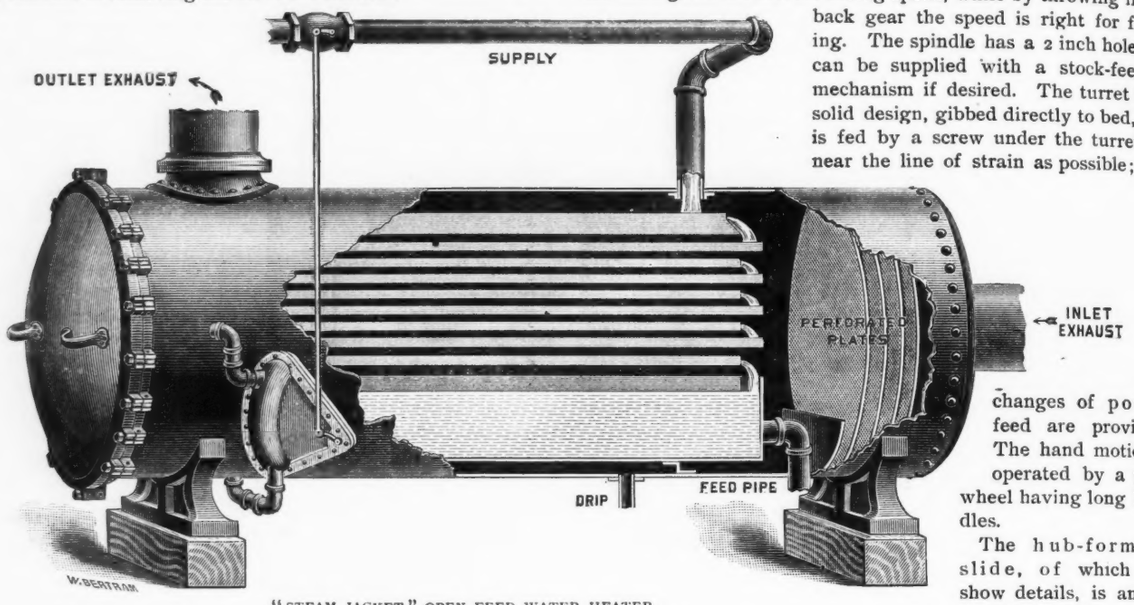
* * *

LIGHTING BY BENZINE.—A German inventor has devised a light made by driving air through pumice stone saturated with benzine, the vapor thus produced being carried through a fine magnesium powder, and proceeding upward through a pipe, consumed in a small flame which is claimed to be of 400 000 candle power.

"STEAM JACKET" OPEN FEED WATER HEATER.

The illustration shows the new "Steam Jacket" Open Feed Water Heater put on the market by Wm. Baragwanath & Son, 49 West Division street, Chicago, Ills. The special points of the heater are:

First: The oil separator, which consists of a series of perforated plates through which the exhaust passes and which proves very efficient in removing the oil of the exhaust.



"STEAM JACKET" OPEN FEED WATER HEATER.

Second: The reservoir of the heater is surrounded by steam, thus maintaining the full temperature acquired by the feed water in its passage over the shelves. Ordinarily in open heaters the steam is simply in contact with the surface of the water in the reservoir which simply obliterates its heating efficiency, besides exposing the water to radiation through the shell of heater. Among the minor points are: The outside connected float so arranged as to be easily accessible in all parts in case of derangement. The removable head which is made very light but strong, with hinged bolts. The gasket of moulded rubber stretched over a boss on the heater ring, where it remains when head is removed and can be used indefinitely. An ordinary sized head can be taken off and replaced in five minutes time. The pans being of steel, are light but strong, and easily removable for cleaning, as is also the bottom reservoir.

This heater has been placed on the market to meet the demand for an efficient and low priced open heater, with the best possible arrangements for accessibility for cleaning and with the most improved method for removing oil.

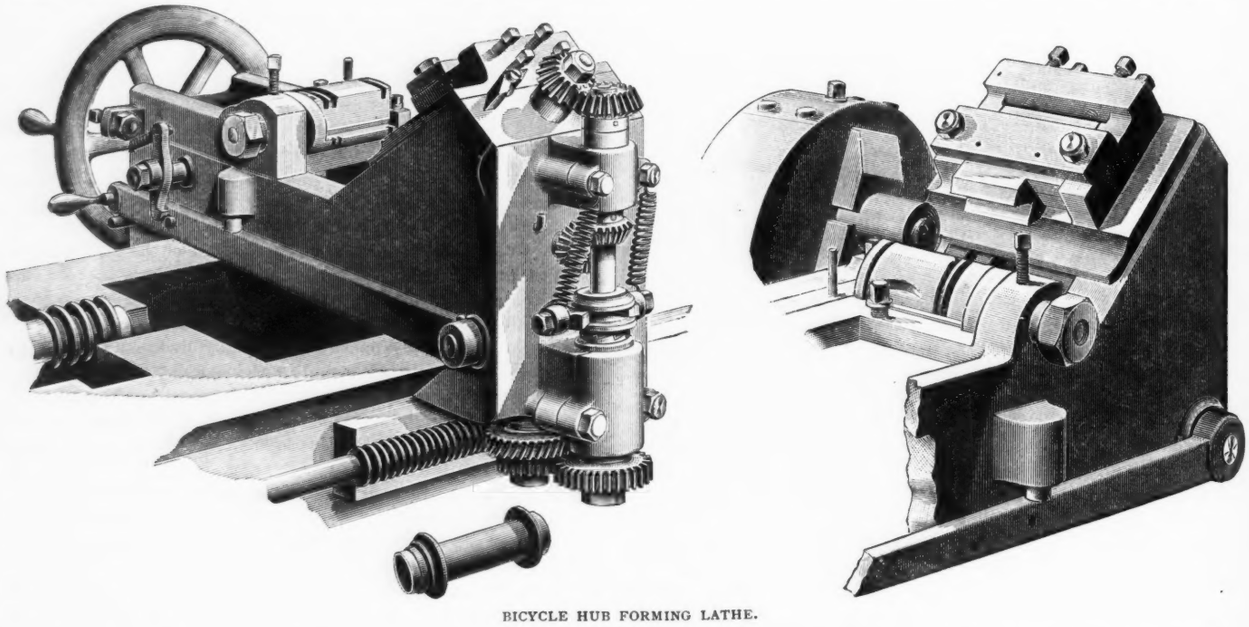
* * *

BICYCLE HUB FORMING LATHE.

This is a very substantial tool, having the headstock cast solid with bed, the spindle being driven by a two-step cone for 5-inch belts and has friction back gear, which is so proportioned that the cone gives the correct boring speed, while by throwing in the back gear the speed is right for forming. The spindle has a 2 inch hole and can be supplied with a stock-feeding mechanism if desired. The turret is of solid design, gibbed directly to bed, and is fed by a screw under the turret, as near the line of strain as possible; two changes of power feed are provided. The hand motion is operated by a pilot wheel having long handles.

The hub-forming slide, of which we show details, is an interesting feature, and is made in box form, gibbed to the bed so as to be rigidly held in position. But one forming cutter is used, of the round type, as can be seen in the illustration, this being easy to set, and held in exact alignment with the spindle.

The back slide moves in dove-tailed ways at an angle of 45 degrees from the plane of the cutter slides; the two slides being geared together so as to feed exactly together as the stock is removed, thus supporting the hub with the greatest nicety against the action of the cutter. The back jaws are made of high-grade tool steel, hardened, ground true and polished. They are held in the slide by a steel clamp and bolts, and both upper and lower jaws are independently adjustable, by means of set screws. A pump is furnished with each machine, which is driven at constant speed by separate pulleys on the countershaft. This supplies an abundance of oil to a manifold oiling device (not shown in cuts), and which is so arranged as to oil both the cutter and the back jaws independently. Power feed for the cutter and back



BICYCLE HUB FORMING LATHE.

slide is furnished, operated by worm and gearing from the rear feed shaft, which also feeds the turret. An automatic stop mechanism is also provided, which stops the feed at any predetermined point.

This method of forming produces very smooth work, as it holds the stock very steadily against all tendency to spring away from the cut, and at the same time is rapid in action, because the hubs can also be bored while the forming cutter is at work, and then when the forming operation is completed the lathe may be run at the cone speed to finish the drilling. A cutting-off tool with adjustable blade is pivoted on the cutter slide, which cuts down the stock after the forming, so that the drill itself removes the hub from the bar.

They are made by the Niles Tool Works, Hamilton, Ohio.

* * *

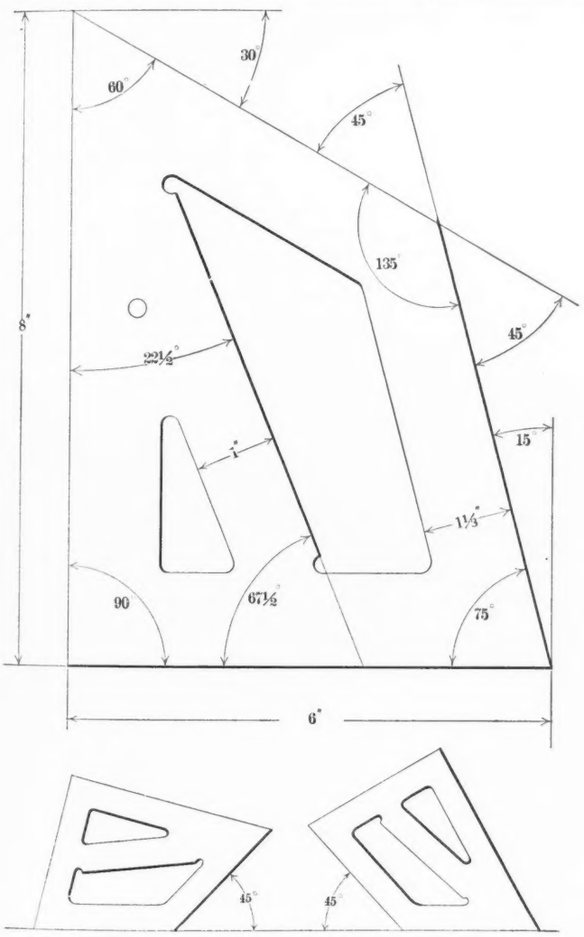
WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

IMPROVED TET ANGLE.

In the March number I note an article on "Handy Drafting Tools," by G. Edward Smith, in which he describes a handy angle (Fig. 2). It being somewhat like a very complete one I have used for about two years, I think it not amiss to hand you inclosed sketch, which will explain itself. The "Tet Angle," if I am not mistaken, was brought out about 1890 by a professor in



IMPROVED "TET-ANGLE," WITH 22½ DEGREES ANGLE INSIDE.

the Smithsonian Institute. I do not know as it is in the market, but certainly should be. You understand it does away with a number of angles on the board, as nearly all the regular degrees are contained in it. I simply add the 22½° on the inside for my own convenience. Besides the angles obtained with the regular 60° and 45°, this one gives you the additional ones of 15°, 22½°, 67½°, 75° and 135°. In using it for right and left hand 45°, it has an advantage over the regular triangle as shown in Fig. 2, as you do not have to turn it over. FRED GRANT HUBBARD.

Brooklyn, N. Y.

CUTTING BOLTS.

Will you kindly give an explanation in your columns why in cutting threads on long bolts in stud machines, the pitch is not true to the pitch of the die? My experience is that the pitch is generally coarser than the pitch of the dies.

Richmond, Va. J. R. G.

MORE ABOUT DRAFTSMEN.

I notice that in the April issue of your paper Mr. Griffin takes exception to some remarks made by Mr. Podunk in the February number. I did not see the February issue (I am always missing something good), but it goes without saying, that Mr. Podunk's conversation with the manager of a tool works was an maginary one, although it is one that could easily be true. During the past 25 years I have worked in about forty shops, in periods of time varying from one hour to six years. In thirty-nine of the forty the cost of labor in the machine shop could have been reduced fifty per cent. if the right kind of gray matter had been used in the drawing room. Of course it would be nice if only first-class men were employed in the drawing room. But did brother Griffin ever stop to think that there are not enough of this class to go around? Draftsmen and designers know how to make pictures with figures on them, but as a rule they know nothing of economical production. I have seen a piece of work which required on an average 5 hours time on the planer changed by one hour's work on the pattern, so that it could be easily done in 45 minutes. And yet the drawing in that shop, in the course of a dozen years, had passed through the hands of two dozen draftsmen and half as many foremen. Those are the men who should get their heads together for 15 minutes and help the poor manager out.

But the draftsman "don't know, don't you know," and the average foreman is in the same boat. A good draftsman does not very often need to consult with a foreman, but he should know enough to leave out *all the unnecessary work*. It is the useless work in the shop that costs, and for this the draftsman is responsible; you can call it mistakes or ignorance. Do not think, Mr. Editor, that draftsmen alone of all men are sinners, "there are others," but when someone springs a truth in your columns, it is really amusing to see the one who is hit jump up and shout, I, sir! no, sir! not I, sir! F. L. JOHNSON.

Lynn, Mass.

HYDRAULICS.

In the April issue of your paper Mr. H. E. Benton asks for a rule for calculating the pressure on an elbow with water flowing through a pipe at say 100 pounds per square inch, velocity 150 feet per minute. Also if the strain on the threads where pipe screws into the elbow is not greater than at other joints, and does not the strain on elbow increase with the velocity instead of pressure of water as with water at rest.

I would suggest to Mr. Benton that if he wants to save money and labor he will do well by using always the simplest of rules, and he will serve his interests in a wonderful manner if he takes special care in avoiding the elaborate rules for the case given by Du Buat, Navier, Etelwein, Kutter, and even those of Nystrom and Weisbach, which are contradictory and unreliable. Use Hawkley's, which are about the best, but use it with a dose of prevention.

The subject, as many other questions in hydraulics which as a rule are the most pleasant lot of discouraging difficulties, should be considered by observation (personal observation) rather than by elaborate rules. The latter will bring you to a sea of complicated formulæ, which is very unsatisfactory.

In well designed elbows the radius of the axis should not be less than *five times* the diameter of the pipe. (There are many in the market as close as two-thirds of the diameter of pipe; avoid them.) The resistance due to friction when the radius of axis is more than five times the bore is really insignificant in computation, much less in practice, but if the radius of axis is about two diameters, then the resistance due to friction is considerable. If the purpose in view is to keep the velocity of discharge constant, then the head should be increased in the same proportion as the friction is increased. If on the other hand the object of computation is to ascertain the strain on elbow due to friction and independent of the discharge, then the resultant of computed friction should be subtracted from the velocity head.

The strain on the threads at elbow will be more than at other joints in the same proportion as the friction is increased at elbow. The strain at elbow with water flowing is more than with water at rest, other things being unchanged.

When the radius of axis is less than four times the diameter of bore the strain on elbow increases considerably. About 8 per cent. of the friction in the rest of straight pipe should be added for each reduction of diameter on the length of radius of axis. On an elbow whose radius of axis is only one-half of the diameter of bore, which is the smallest possible bend, the strain is enormous, and the friction is fully 50 per cent. more than at straight piping.

Coxsackie, N. Y. J. DE D. TEJADA.

GEAR WHEELS.

I regret very much that my answer to Mr. S. Webber in regard to question of stress in gear-teeth was not explicit enough. I do not, however, see that I could improve much upon what I said in the February issue, excepting that I use the well-known formula for cantilevers which, for a rectangular section, is $P = \frac{b\,d^2\,s}{6\,l}$ when P = pressure or load, b = breadth, d = depth, l = length of cantilever and s = stress of material per square inch (not cubic inch). This formula is considered correct if the stress per square inch does not exceed the elastic limit of the material. I presume Mr. Webber uses a formula like the following: $P = \frac{b\,d^2}{l} \times \frac{8000}{f}$, when f stands for factor of safety; then if f is 16, which Mr. Webber uses, the equation would read $P = \frac{b\,d^2}{l} \times 500$, which would be the same as if I make S = 3000 in formula for cantilevers, thus, $P = \frac{b\,d^2}{l} \times \frac{3000}{6}$. It seems the difference in results arrived at by each of us is due to the fact that Mr. Webber takes the same factor of safety for all speeds, whereas I do not. He also considers the entire load never taken by one tooth.

As to the inquiry what I meant by a pressure of 840 pounds per inch width of face, would say, if a wheel 5 feet in diameter and 10-inch face has to transmit 400 HP. at 100 revolutions per minute, the pressure at the pitch circle will be nearly 8400 pounds and for a wheel having 10 inch face the pressure per inch of width of face will be $\frac{8400}{10} = 840$ pounds. JOHN L. KLINDWORTH.

Allegheny, Pa.

BOILER REFORM.

I was much interested in the article on this subject by John J. Hogan, and think he is right in most of what he says, especially the portion relating to the application of extreme heat to tubes which contain steam, which effectually prevents the entrance of water. He is right in saying it is a violation of natural laws, and I hope to hear more from him on the subject.

Your account of the Edison lawsuit interested and amused me, and think the changing of the feed from top to bottom was a very sensible move. My battery of three 80 HP. return tubular boilers keeps in fine condition, which shows that the lower tubes must get plenty of water. ARTHUR STONE.

Chattanooga, Tenn.

CARBIDE-ACTYLENE.

The *Progressive Age*, true to its name, sent a committee of experts consisting of Prof. Edwin J. Houston, Drs. A. E. Kennelly and L. P. Kinnicutt to examine the plant of the Willson Aluminum Co., at Spray, N. C., and report on the cost of producing calcium carbide by their methods. This they found to be $32.767 per ton, of which $14.39 is for material. They seem to think, however, that with a more favorable location as to freight and a larger plant it can be reduced to $20.00. These figures give a basis for calculation which are the most reliable yet made public.

* * *

THE PROVIDENCE LINE OPENING.

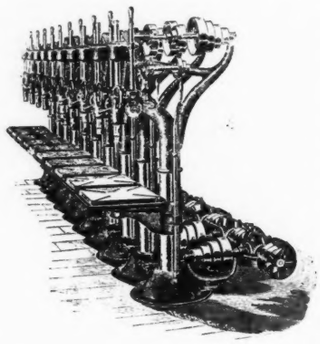
The announcement of the opening of the Providence Line Monday, May 11th, will be hailed with delight by all "lovers of comfortable travel." This line is without exception the route for all travellers desiring to visit Boston, Providence, Worcester and New England and the Maritime Provinces, combining the advantage of the longest water route and shortest rail ride, assuring passengers a full night's rest with early arrival at destination, and the sail through Narragansett Bay and on the Providence River in the early morning or evening is a delightful feature and will well repay an early riser.

A novel feature of this line, possessed by no other on the sound is the main deck cafe, where passengers may, while listening to a superb orchestra, enjoy the cuisine of a first class club or restaurant. The most distinctive feature, however, of this line, and one so often spoken of by travellers, is the uniform courtesy shown by all its officers and employees to travellers, which is the more appreciated because so often denied the travelling public.

* * *

A ROW OF DRILLS.

At first sight these appear to be a gang of drills, but closer inspection shows ten single drills made by W. F. & John Barnes Co., 231 Ruby Street, Rockford, Ill., set close together and having the advantage of being separable if desired.



The cut shows ten of their 20 inch drills as furnished to one of the largest bicycle manufacturers in this country. These are equipped with self-feed, automatic stop, square table with T slots and groove for oil drip. A quarter turn device in the counters enables them to be set closely and at right angles to line shaft so as to economize floor space. These are said to be more satisfactory than the regular gang drills as well as being considerably lower in price, a feature to be considered nowadays. Larger sizes can also be grouped in the same manner.

* * *

MANUFACTURERS' NOTES.

THE GEOMETRIC DRILL CO., of Hartford, Conn., announce that they are to occupy new quarters at No. 150 Asylum street after May first. This change is necessitated by their increasing business in geometric boring tools and their other specialties.

BUFFALO ASSOCIATION No. 16, N. A. S. E., is making extensive preparations for the coming convention in that city, and intends to make it a red-letter event in its history. The press committee is keeping the various papers informed of the plans.

THE Directors of the Davis & Egan Machine Tool Co., held their regular quarterly meeting Monday and declared a dividend of three per cent. for the first three months of this year. The company are now working full on bicycle machinery and export orders, and are making arrangements at the present time to largely increase their capacity.

THE BUCHEL MACHINE WORKS, New Orleans, La., send us a new foundry brush, consisting of a hardwood handle into which the flat wire teeth are firmly set, being forced directly into the wood. This makes a very solid construction and produces a brush which should give excellent service in cleaning castings in the foundry.

NO MATERIAL has so strong an affinity for iron and steel as pure, soft flake graphite, and for bicycle chains and sprockets there is nothing equal to it. The Dixon Crucible Co., Jersey City, N. J., select their choicest material from unlimited stocks, and, after analyzing all other cycle chain lubricants in the market that they could find, do not hesitate to say that Dixon's No. 691 Cycle Chain Graphite is absolutely without an equal for preventing rust and wear of chain and for insuring ease and comfort in riding.

THE WALWORTH MFG. CO., 14 Oliver street, Boston, Mass., are about putting a new line of pipe dies on the market which will be known as the "Rough and Tough," which exactly explains their peculiarities. They are made of a superior quality of steel and have no external finish whatever—hence the name Rough and Tough. These dies have been used in their own works for some time and have given such satisfaction as to lead to the belief that they will be appreciated by others.

AFTER much experimenting, Jenkins' Brothers announce that they have obtained a packing that meets all requirements in their new "Jenkins '96." Reports from prominent engineers who have given it a trial claim that not a fault can be found with it. It is simply an improvement on the old Jenkins packing and is now suitable for all pressures of steam and will not rot, burn, blow or squeeze out under any conditions, and in addition will last for years in a joint. Another advantage is that the joint can be broken repeatedly and the packing used again and again. Although these are broad claims, this well-known house, Jenkins Brothers, 71 John street, New York, are willing to stake their reputation on it.

THE DIAMOND MACHINE CO., Providence, R. I., have found business very good during the last three months. While January was somewhat dull, yet February and March have each shown a decided improvement and there is a good outlook for activity in the line of grinding and polishing machinery. During the fall there was a heavy demand from bicycle manufacturers, which has fallen off somewhat at the present, although concerns already established are sending in duplicate orders and many new companies are starting this spring. The tendency of manufacturers to look for some machine carrying an emery wheel on which to do certain work has been productive of considerable business,

and they have at the present time a large number of inquiries and orders on hand for special grinding machinery.

THE VAN AUKEN STEAM SPECIALTY CO., C. P. Monash, manager, 201 South Canal street, Chicago, send us a very neat 6-inch 45 degree celluloid triangle, illustrating some of their specialties. Such an advertisement as this will be preserved and used constantly.

* * *

BUSINESS.

NO CHARGE IS MADE FOR THE INSERTION OF BONA FIDE ITEMS UNDER THE ABOVE HEAD. FOR FURTHER PARTICULARS, ADDRESS THIS OFFICE.

WE have an inquiry for machinery (for export) for knitting nets and seines such as are used by fishermen. Makers can address this office.

* * *

FRESH FROM THE PRESS.

HOW TO SAVE MONEY IN R. R. BLACKSMITHS' SHOPS BY THE USE OF BULLDOZERS AND HELVE HAMMERS. Orville H. Reynolds, M. E. Associate Editor "Locomotive Engineering," 256 Broadway, New York. 18 pages, 6x9 inches. 25 cents.

This contains information of great value to railroad and other shops using these tools, as it illustrates working drawings of a large number of dies used in railroad work by one progressive railroad shop. There is too little attention paid to the possibilities of these tools, and the facts contained in this little book are worthy of careful study. It is carefully written, and the clear manner of the author, who is well-known in modern railroad work, makes it worth many times the price.

STEAM ENGINE CATECHISM. Robert Grimshaw, M. E. Norman W. Henley & Co., 132 Nassau street, New York. Tenth Edition. 413 pages, 4x5¾ inches. Price, $2.00.

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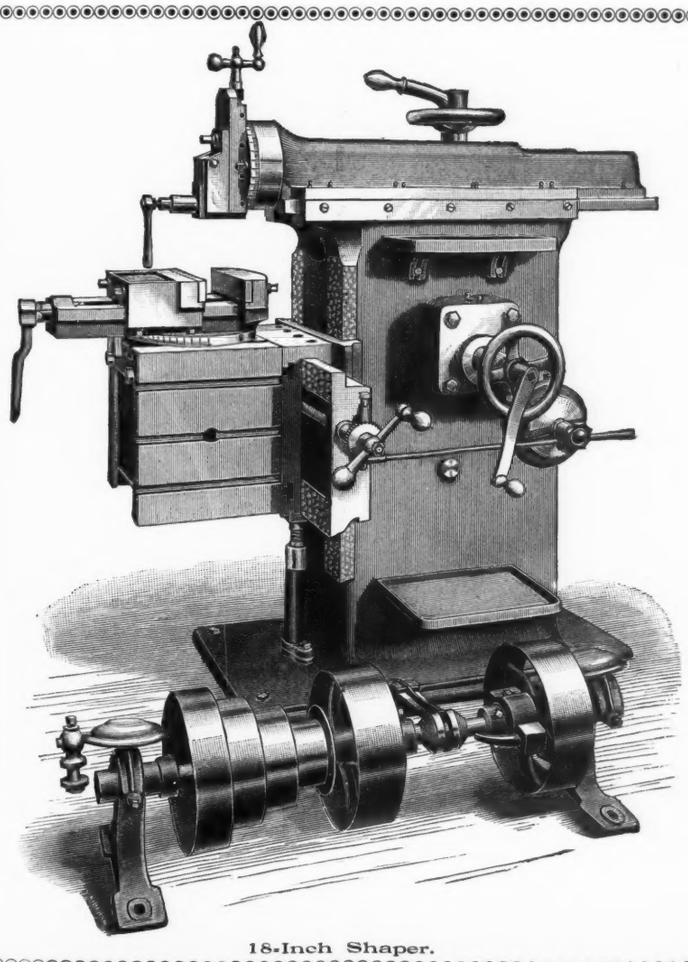

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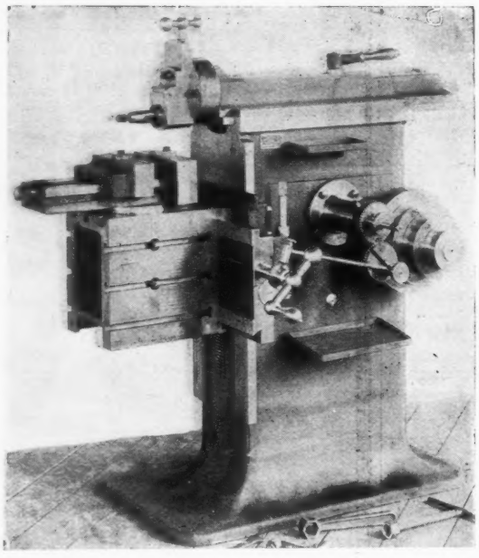

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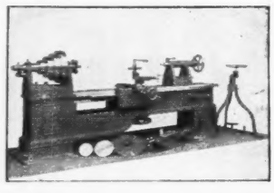

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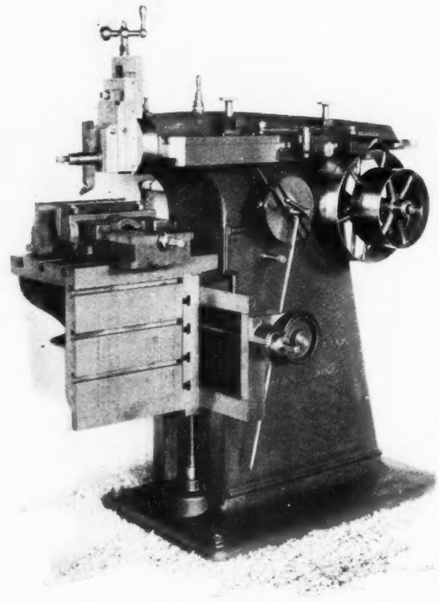

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